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Arishiro et al.

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(54) **MANUFACTURING APPARATUS FOR MANUFACTURING ELECTRONIC MONOLITHIC CERAMIC COMPONENTS**

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(73) Assignee: **Murata Manufacturing Co., Ltd.**, Nagaokakyo-Shi, Kyoto-Fu (JP)

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(21) Appl. No.: **09/893,399**

(22) Filed: **Jun. 29, 2001**

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**
B32B 38/18 (2006.01)
B32B 38/10 (2006.01)
C03B 29/00 (2006.01)

(52) **U.S. Cl.** **156/362**; 156/89.12; 156/247; 156/556; 156/563

(58) **Field of Classification Search** 156/538, 156/539, 556, 559, 350, 89.11, 89.12, 89.16; 221/97, 98, 99; 209/706; 211/49.1, 50, 211/59.2, 126.15, 162
See application file for complete search history.

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Primary Examiner—Melvin C Mayes
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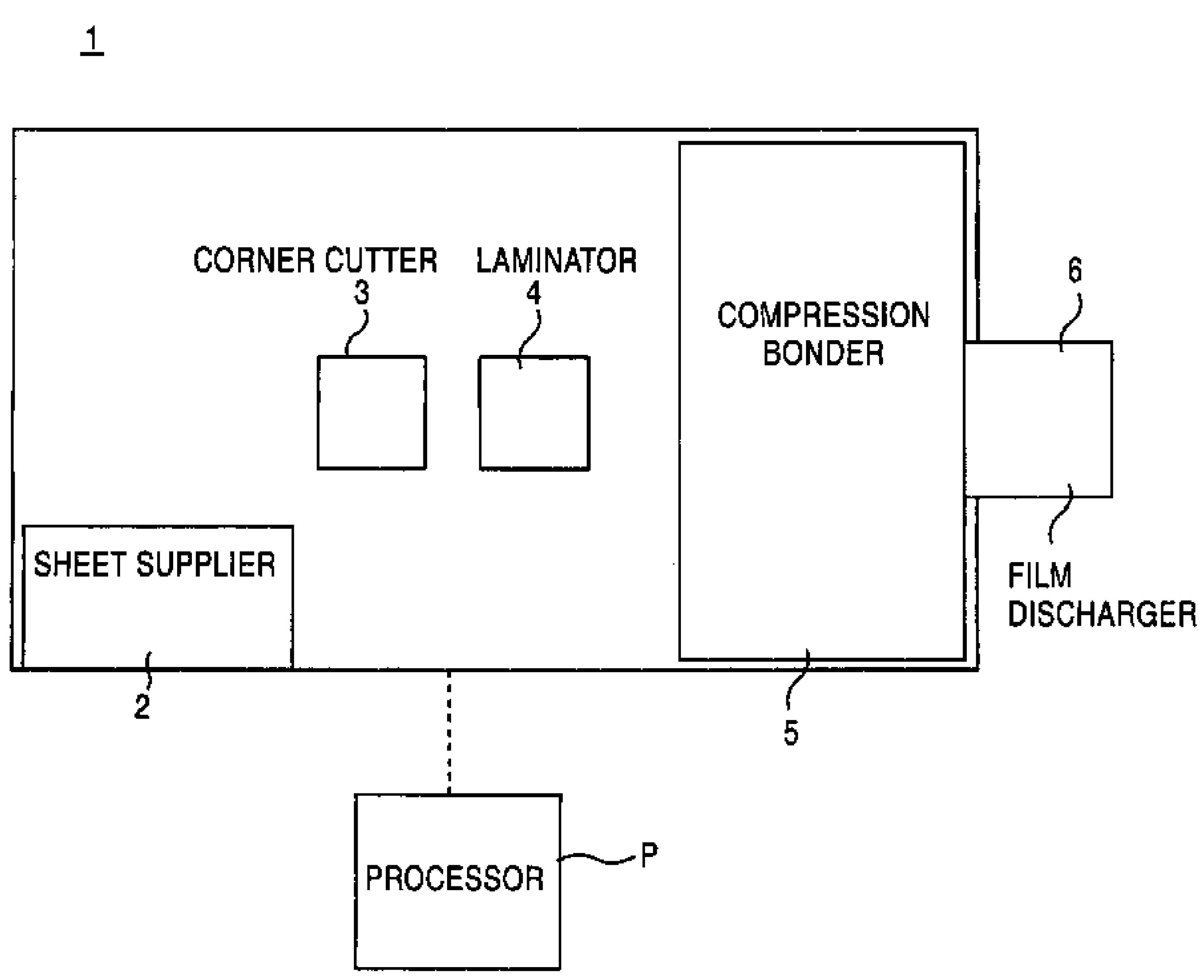
(57) **ABSTRACT**

A manufacturing apparatus for manufacturing electronic monolithic ceramic components, including a sheet supplier for supplying a plurality of ceramic green sheets of a plurality of types in a predetermined order, and a laminator for laminating the ceramic green sheets supplied by the sheet supplier. A plurality of trays is set in two vertical columns in a rack which is vertically movable. Each tray holds a stack of a plurality of ceramic green sheets of the same type. A particular tray positioned to a predetermined level by the vertical movement of the rack is drawn by a tray drawer device, and one ceramic green sheet is picked up from the tray, and is then conveyed to the laminator. The utilization efficiency of area in the sheet supplier is thus increased.

10 Claims, 14 Drawing Sheets



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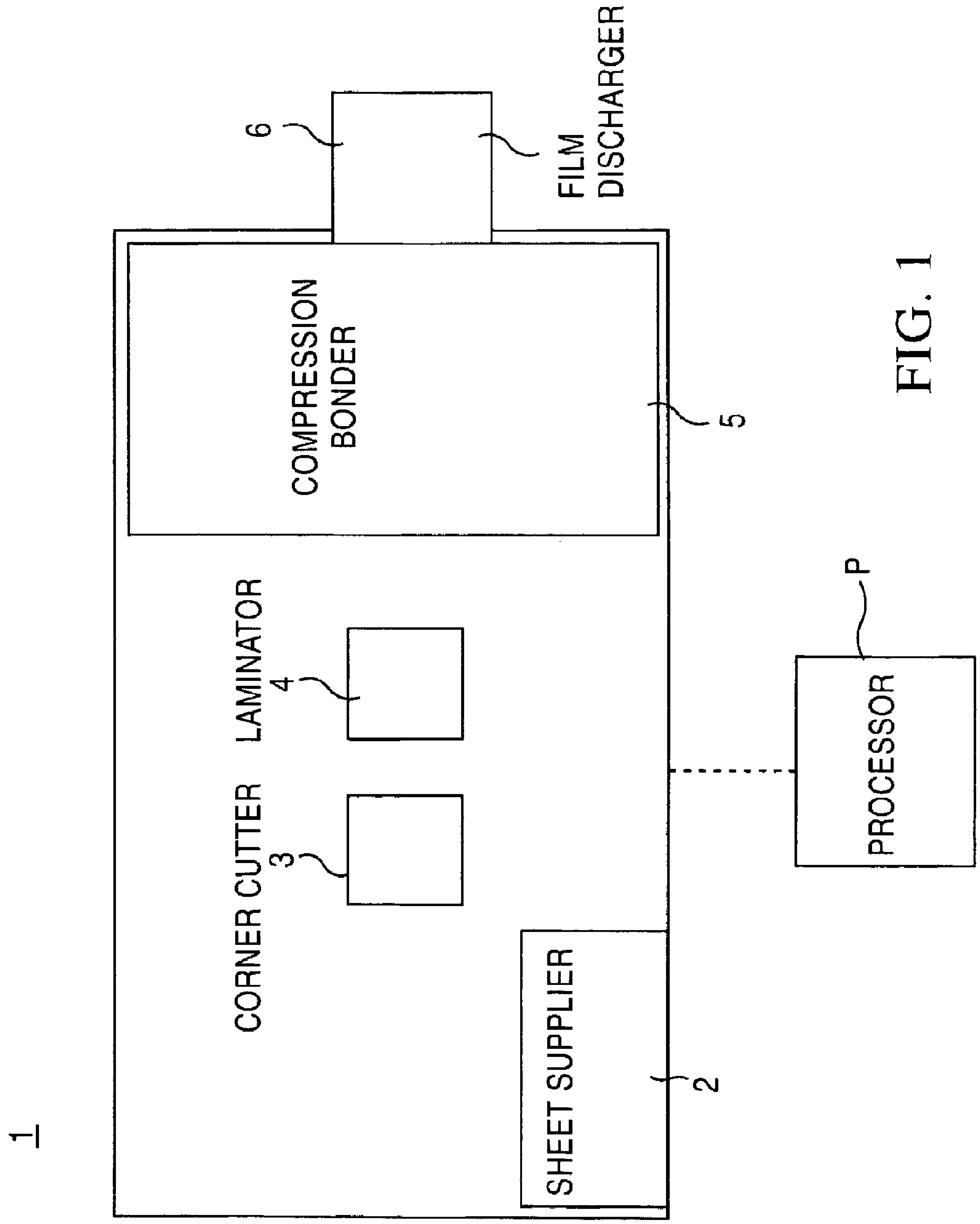

1
FILM DISCHARGER
6
COMPRESSION BONDER
5
LAMINATOR
4
CORNER CUTTER
3
SHEET SUPPLIER
2
PROCESSOR
P

FIG. 1

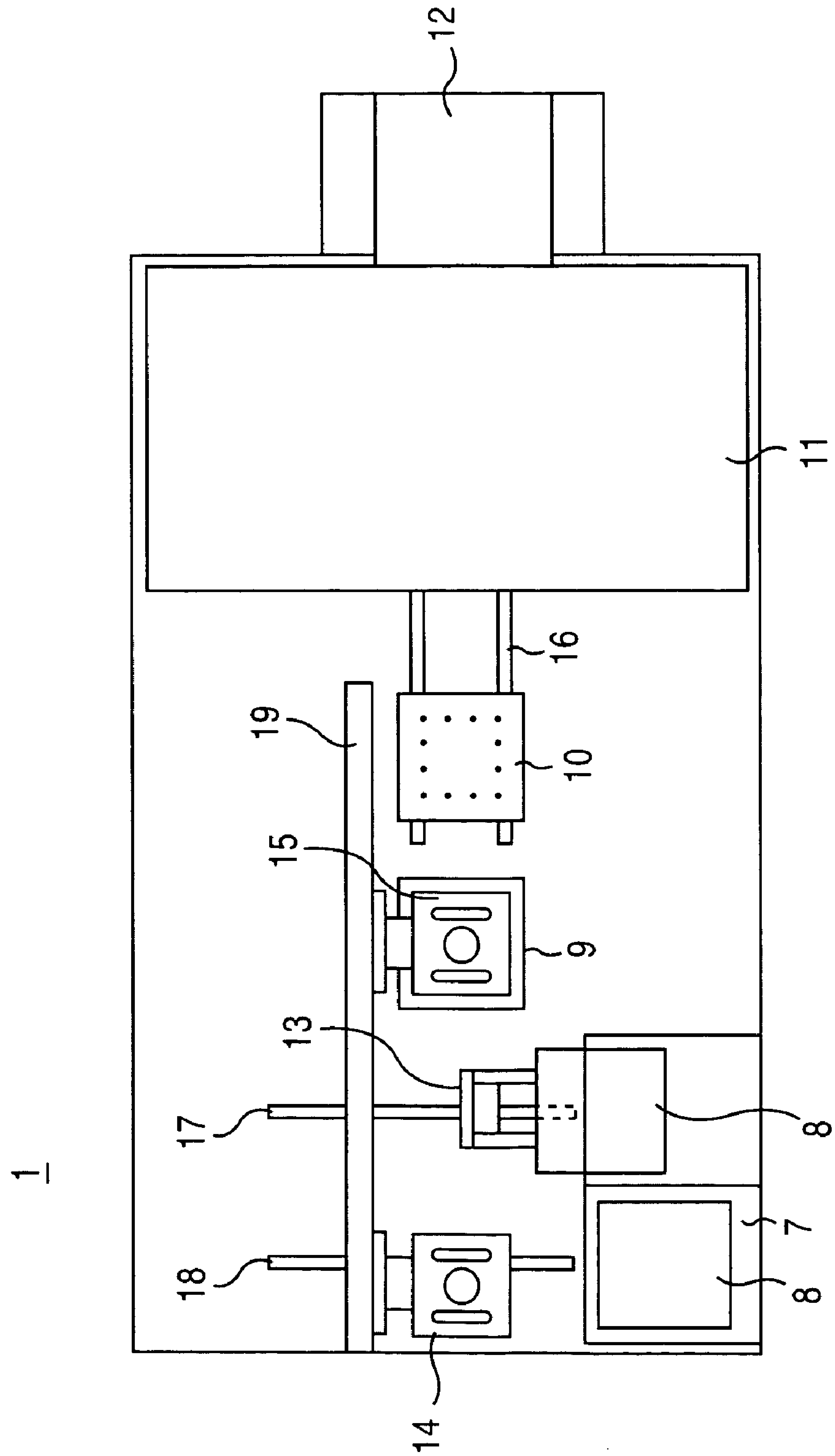


FIG. 2

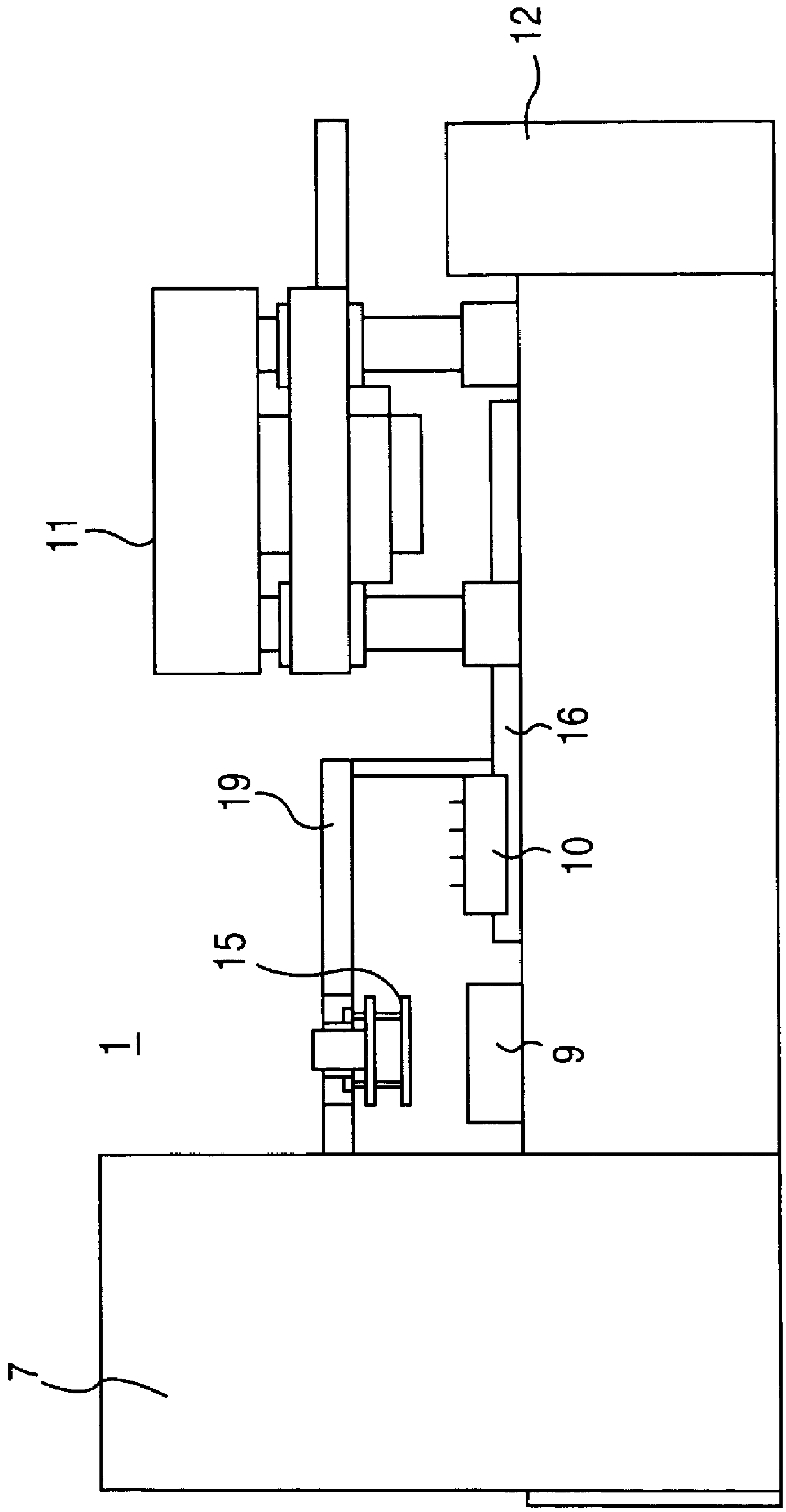


FIG. 3

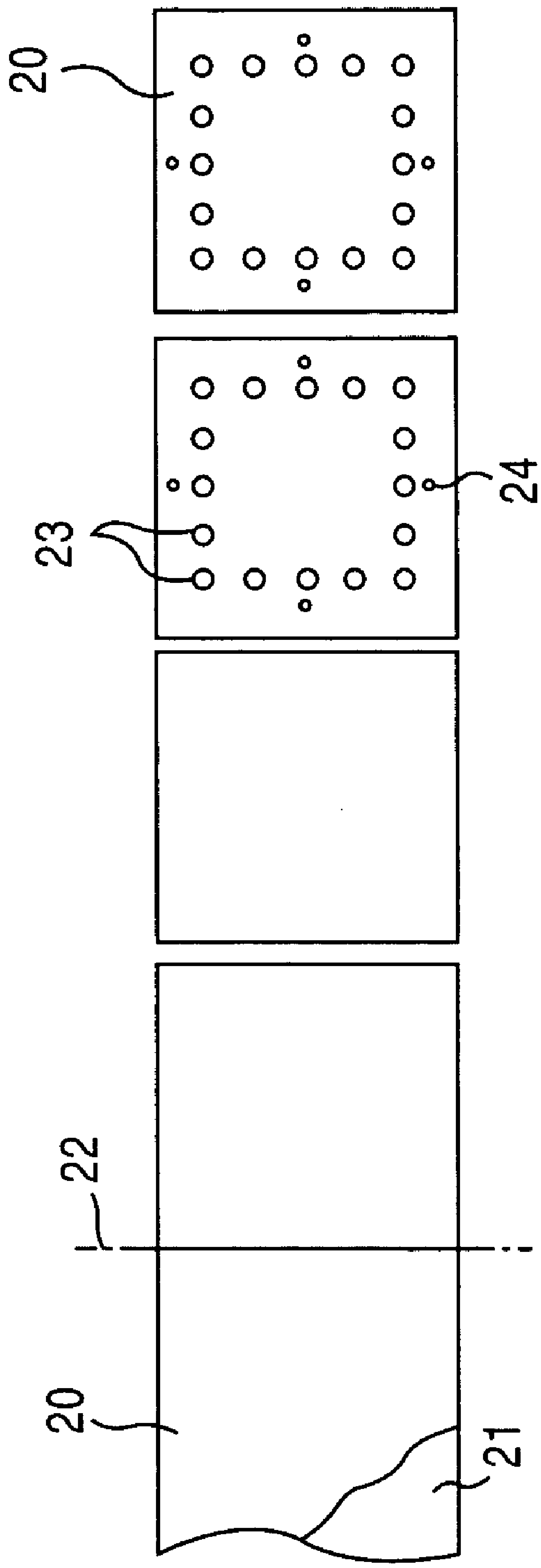


FIG. 4

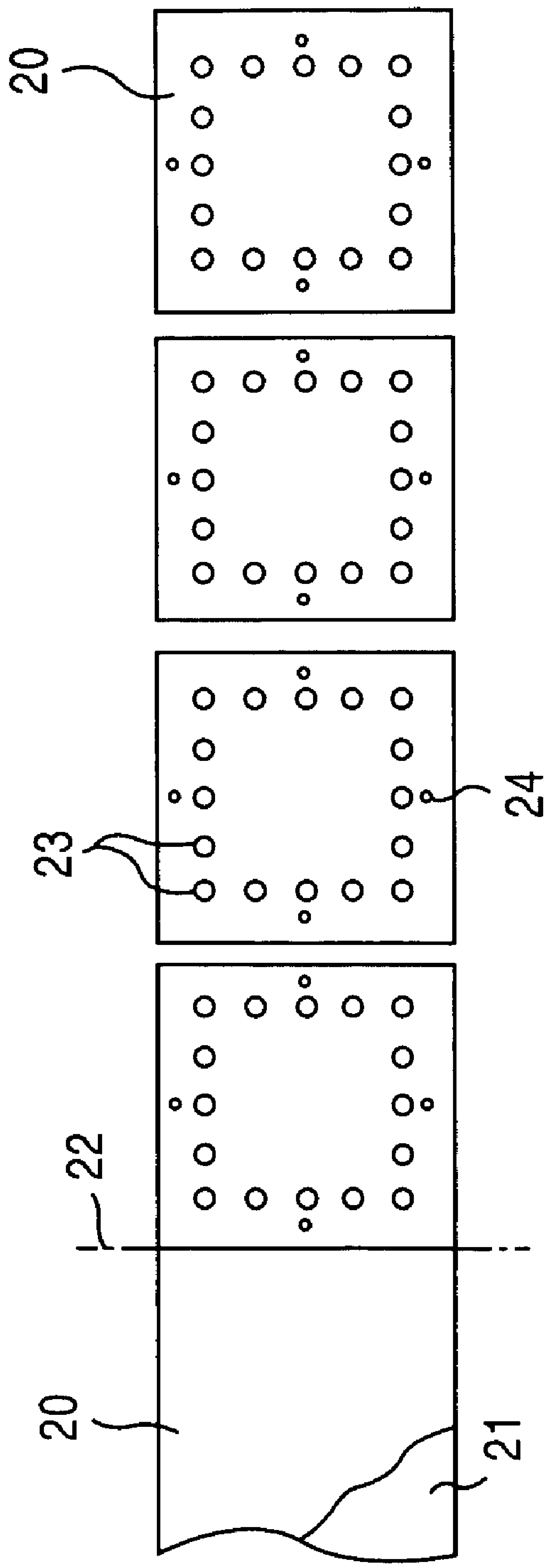


FIG. 5

FIG. 6

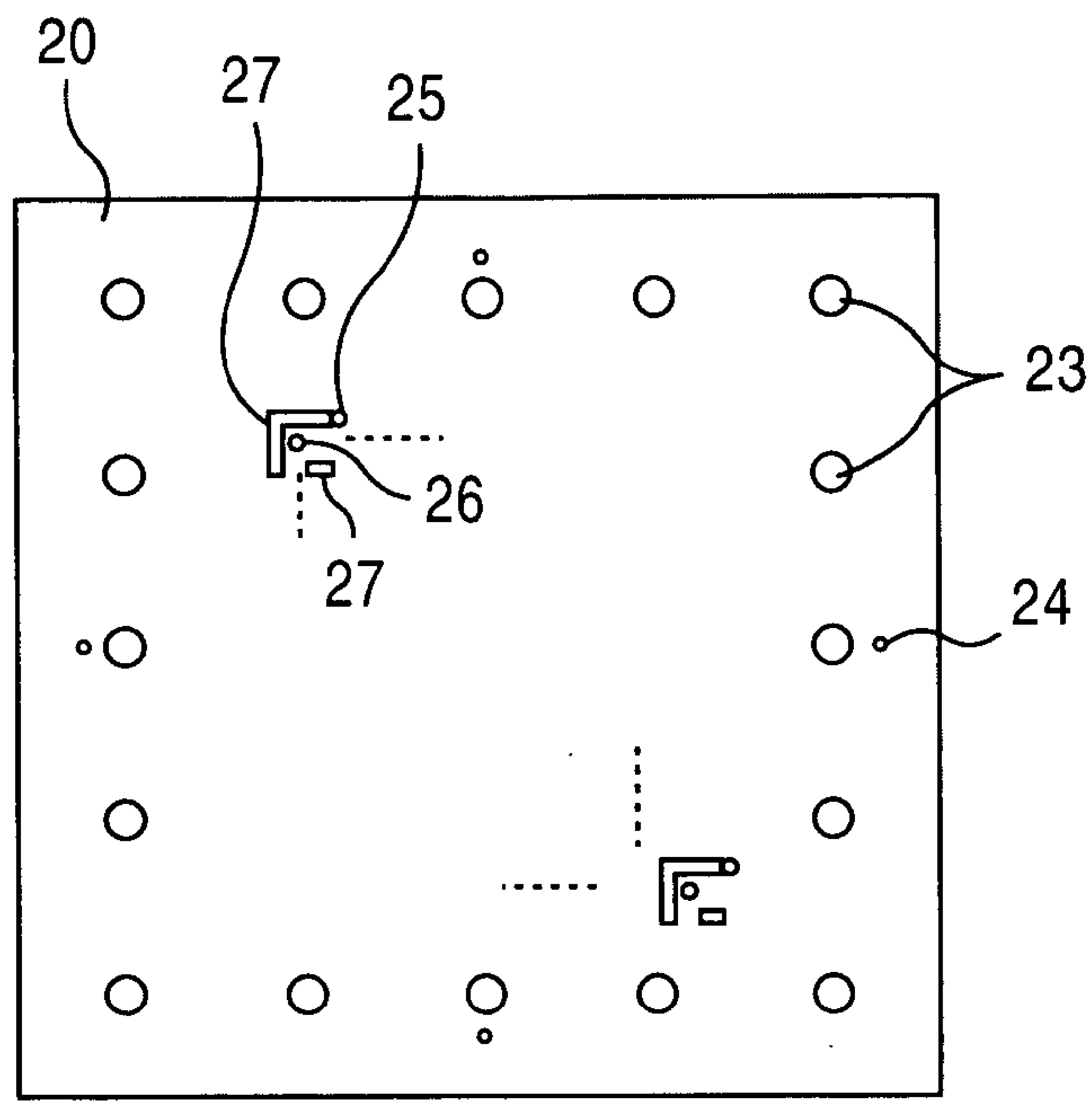


FIG. 7

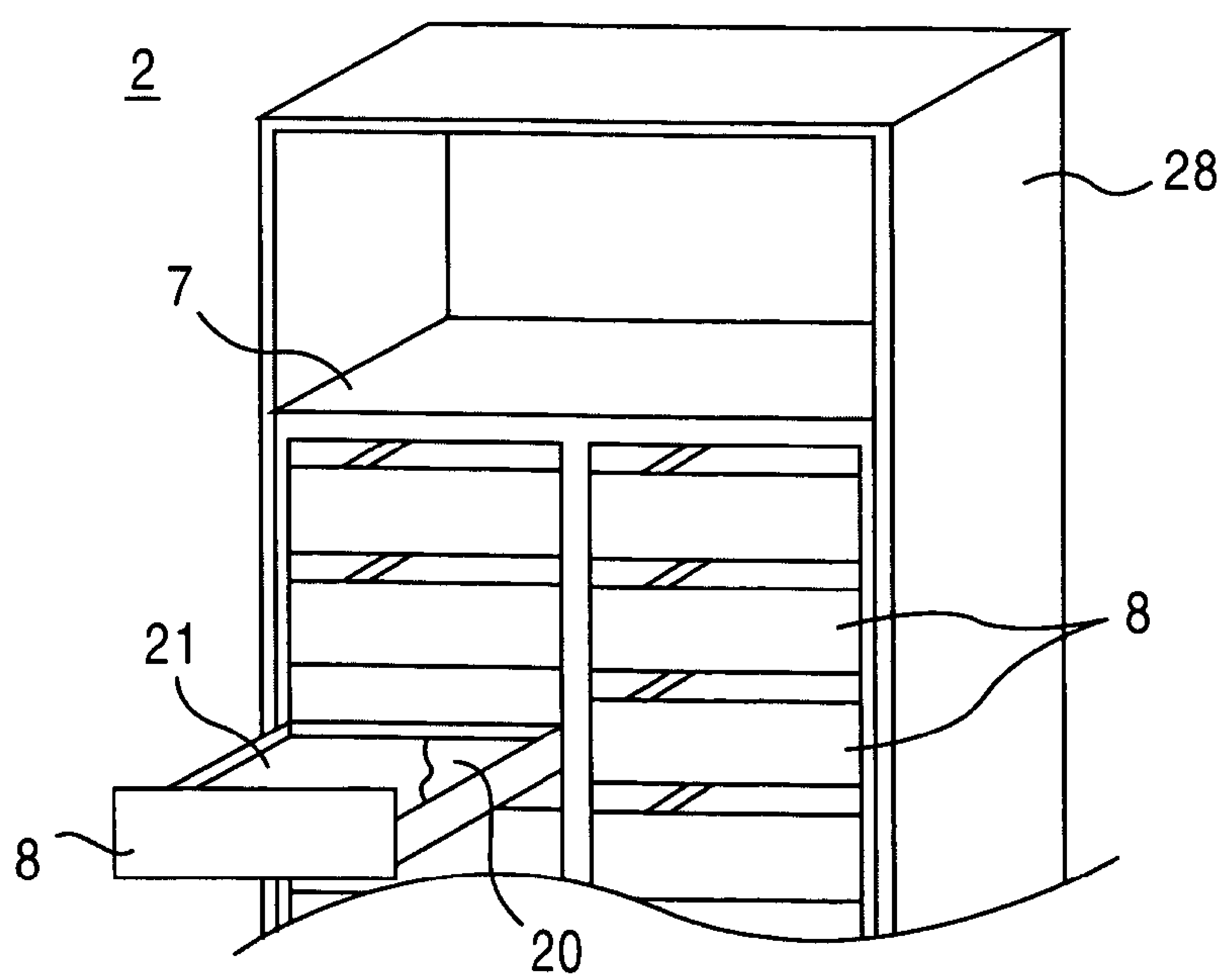


FIG. 8

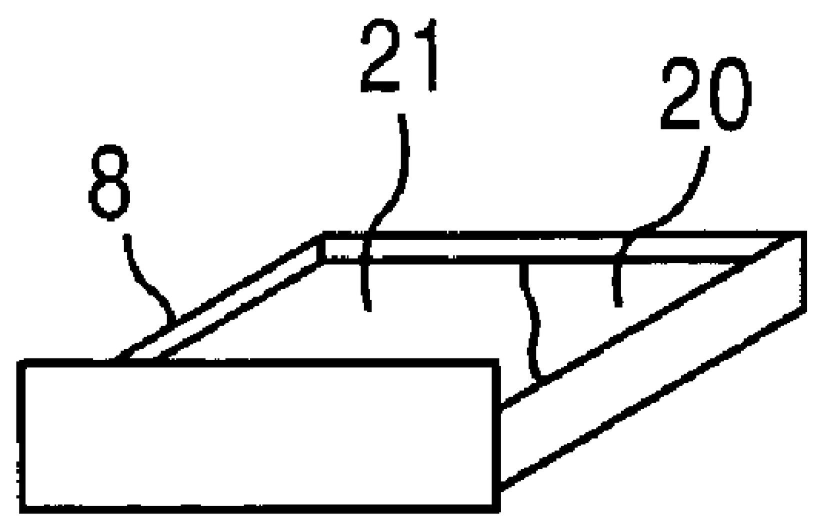


FIG. 10

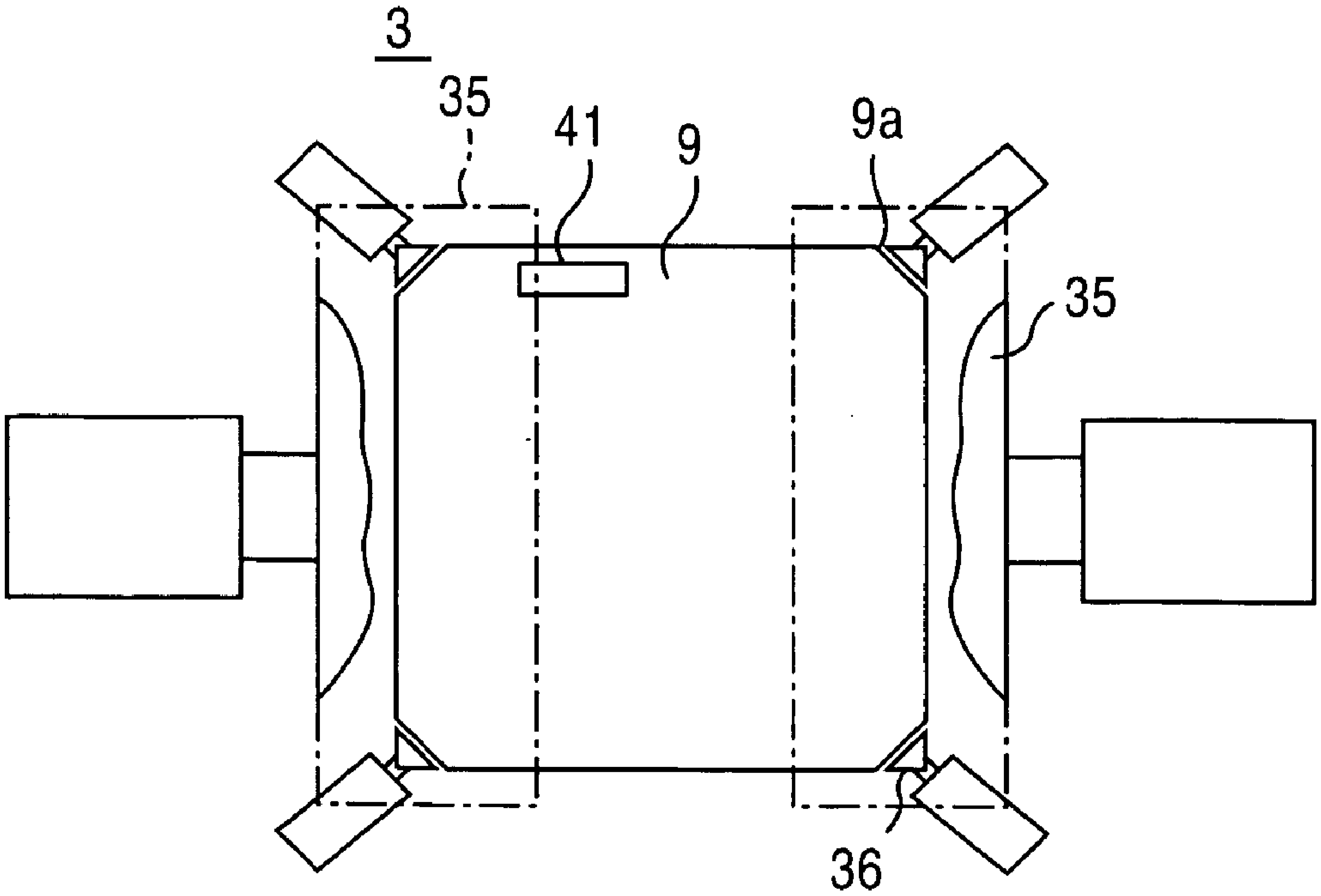


FIG. 9

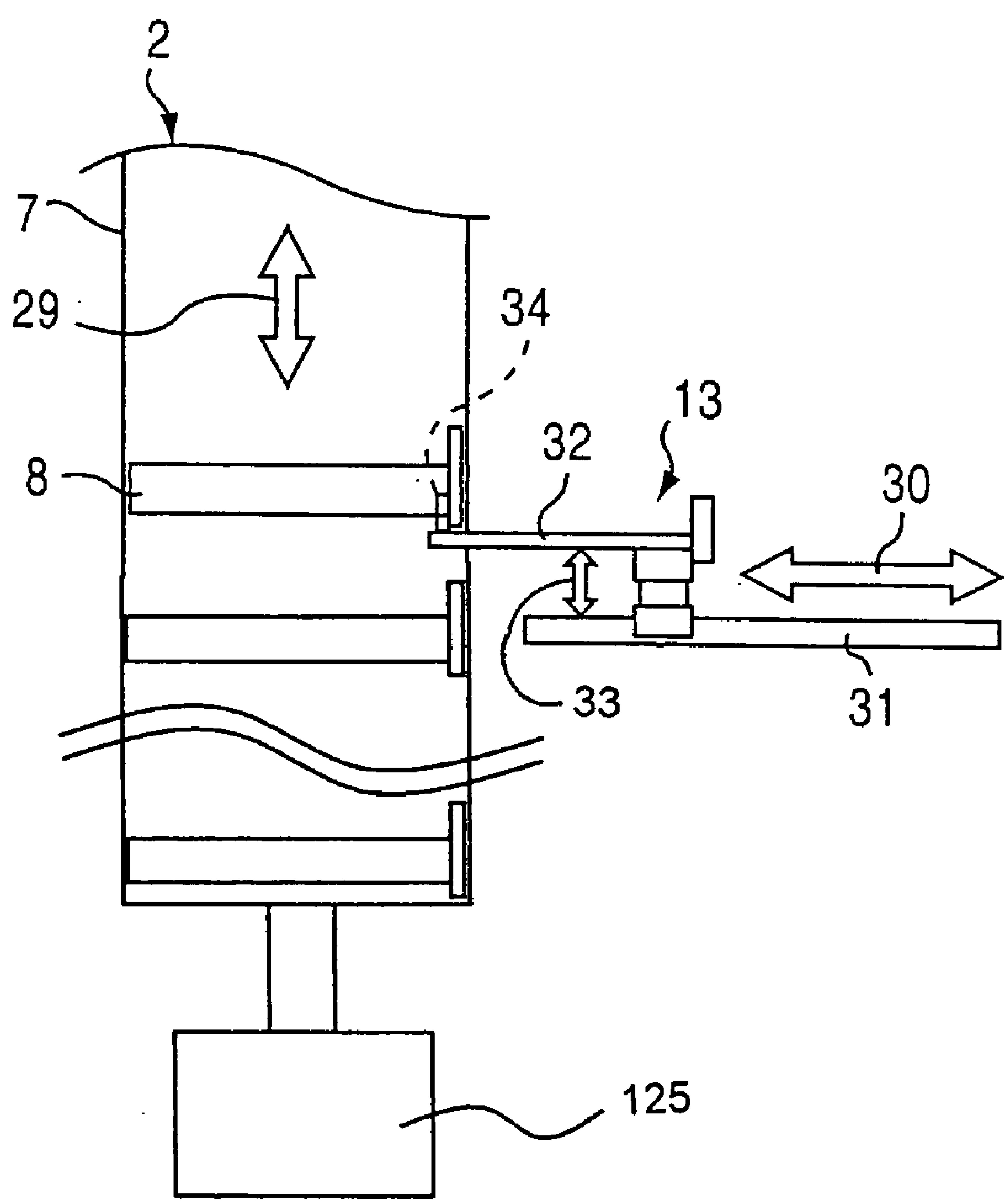


FIG. 11

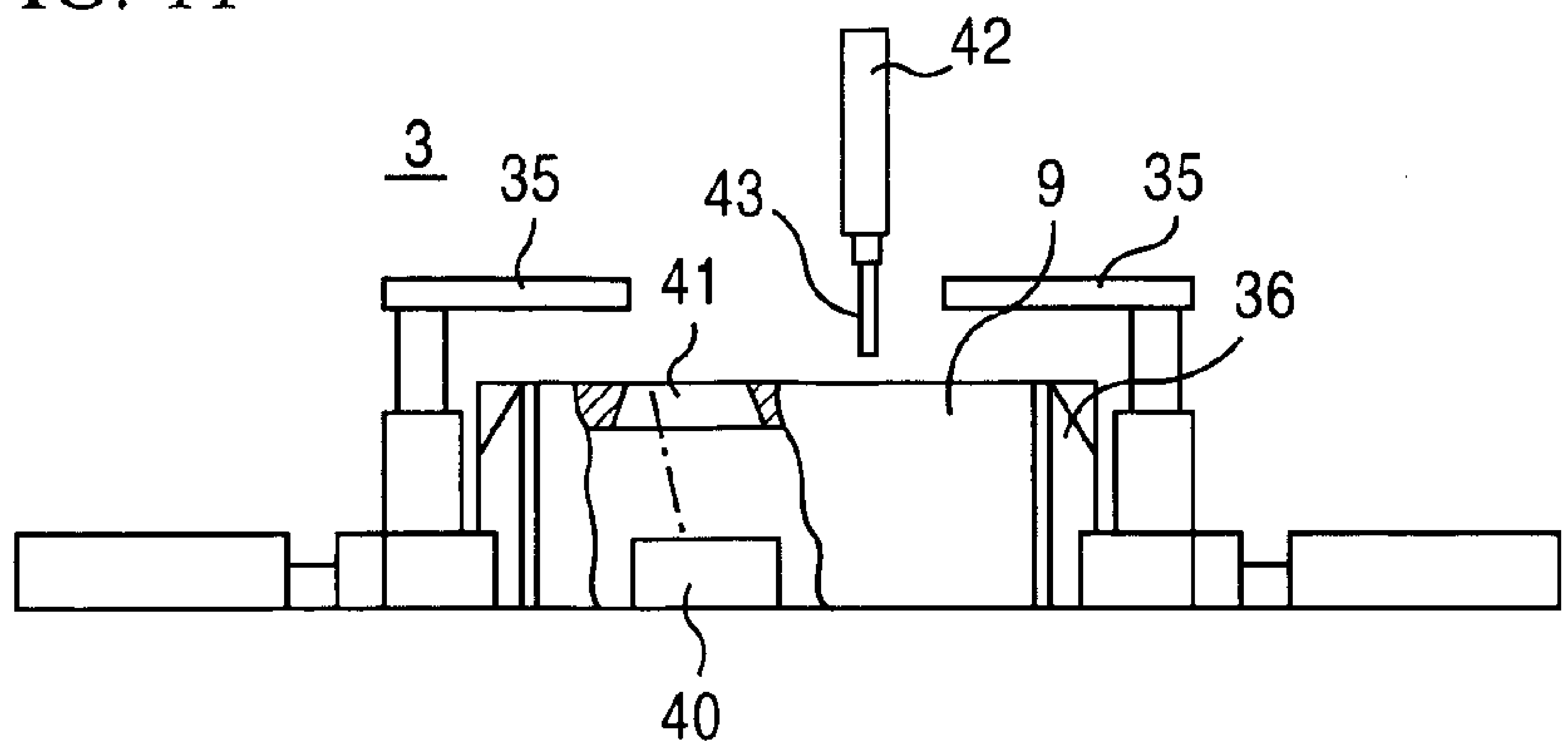


FIG. 12A

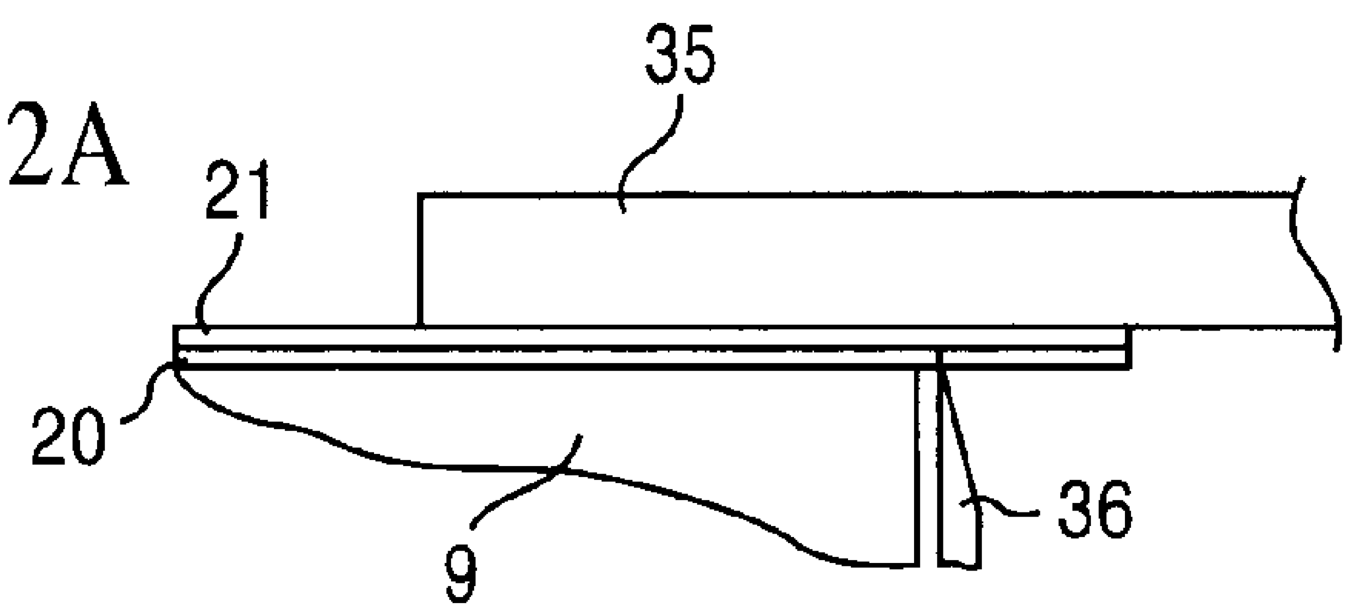


FIG. 12B

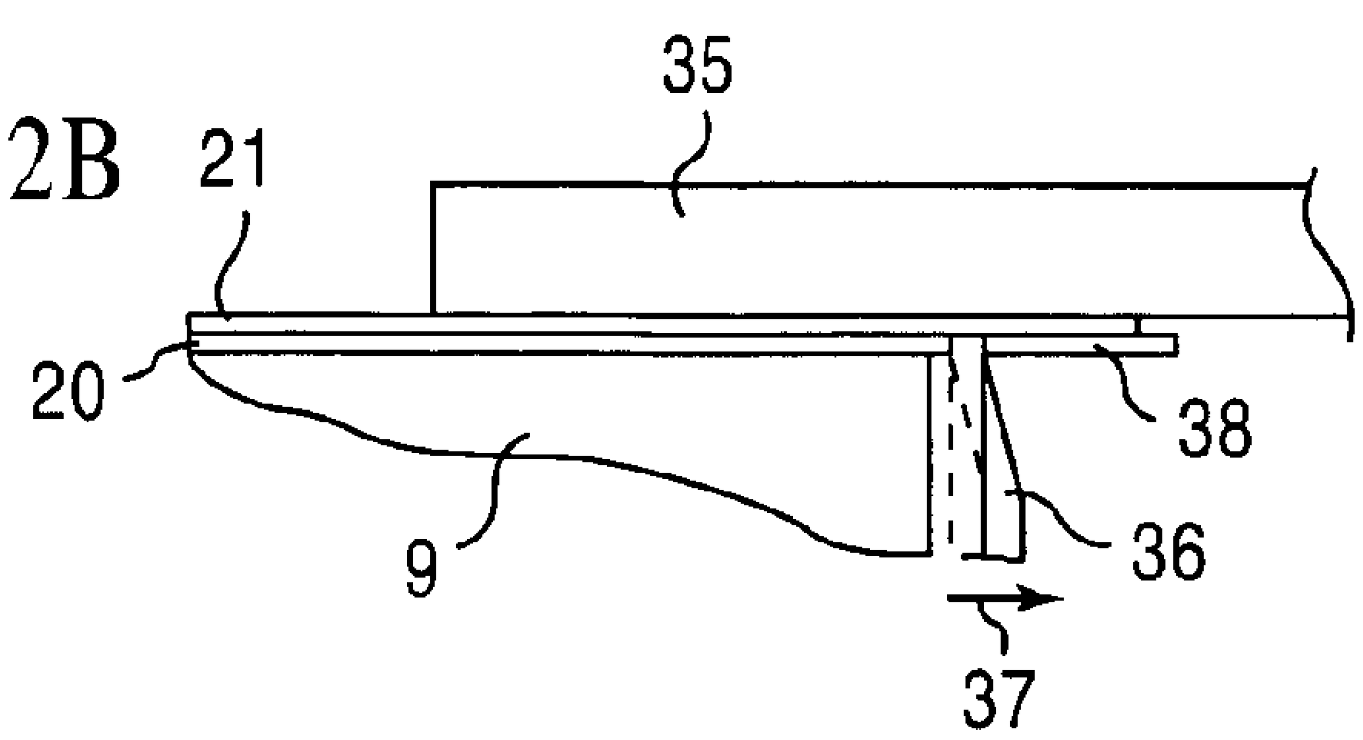


FIG. 12C

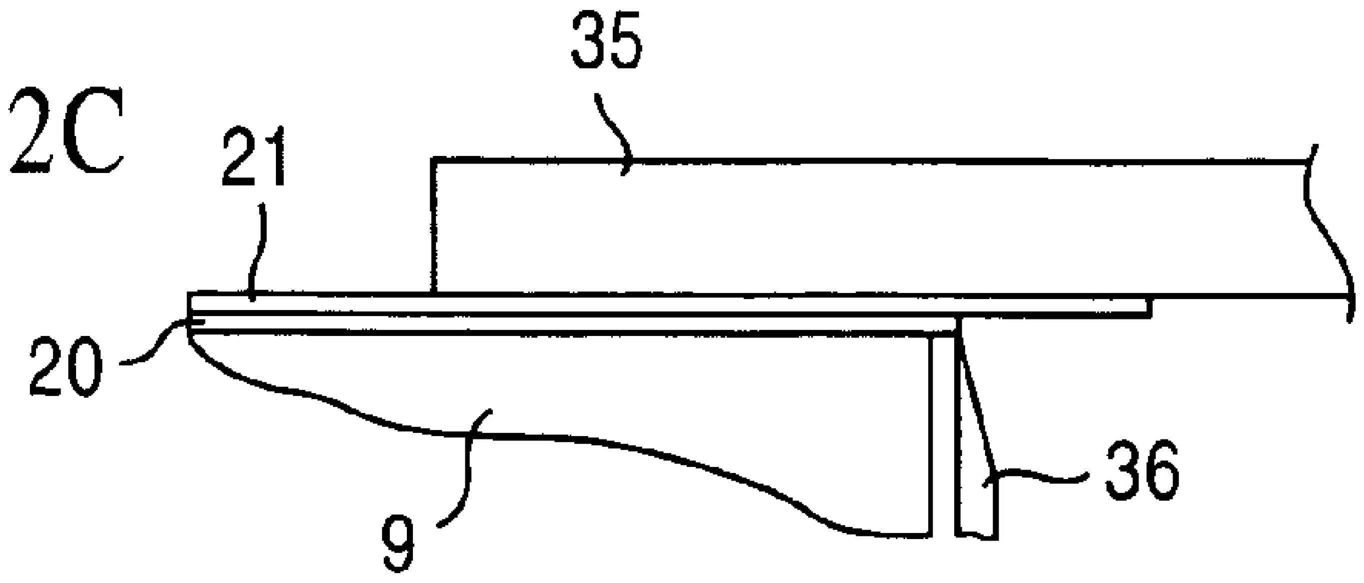


FIG. 13

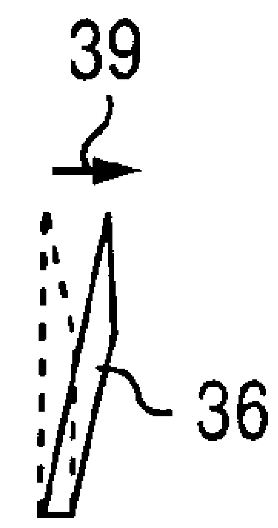


FIG. 14

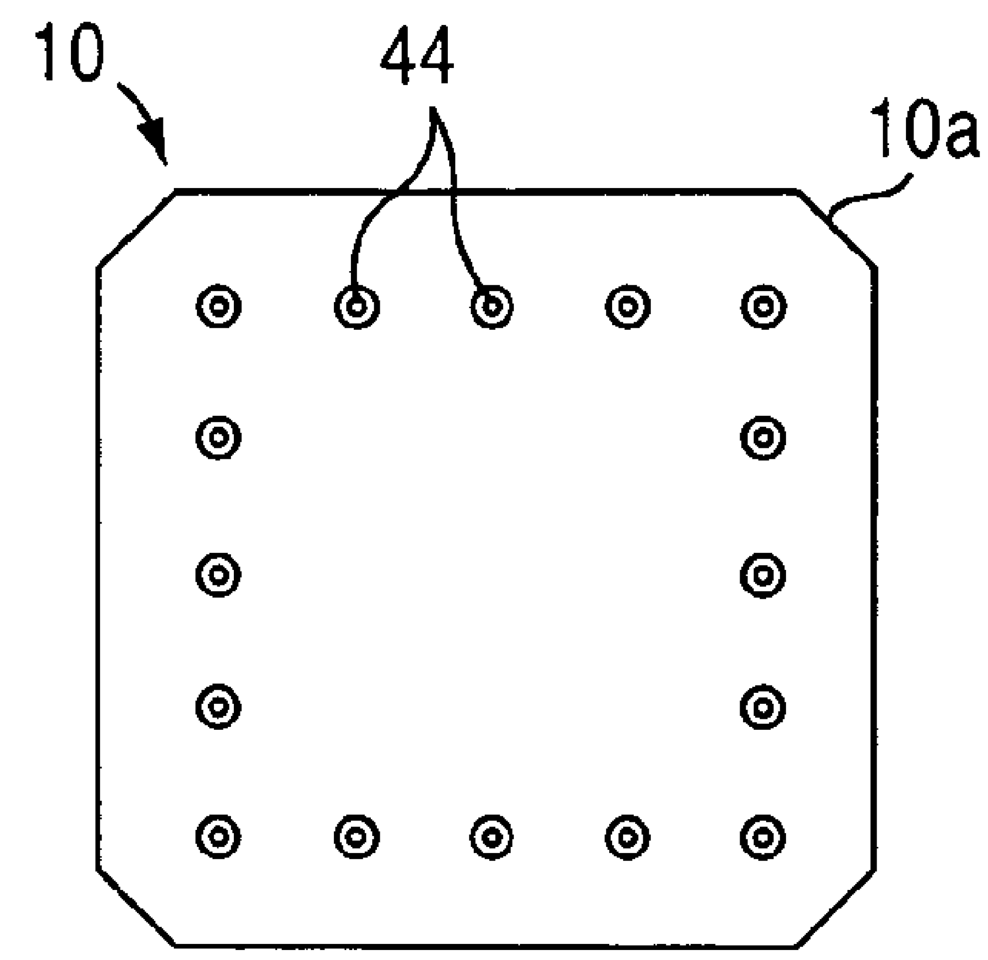


FIG. 15

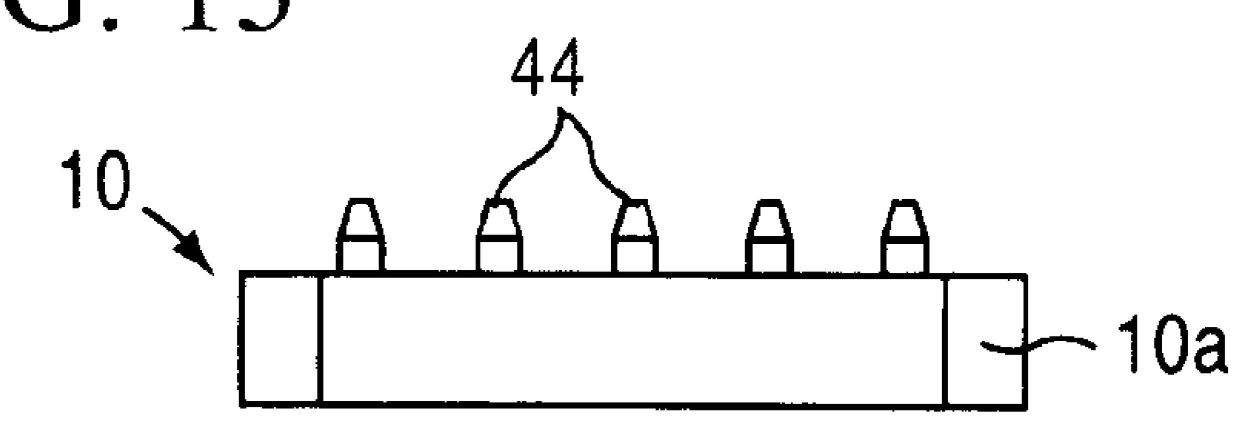


FIG. 16

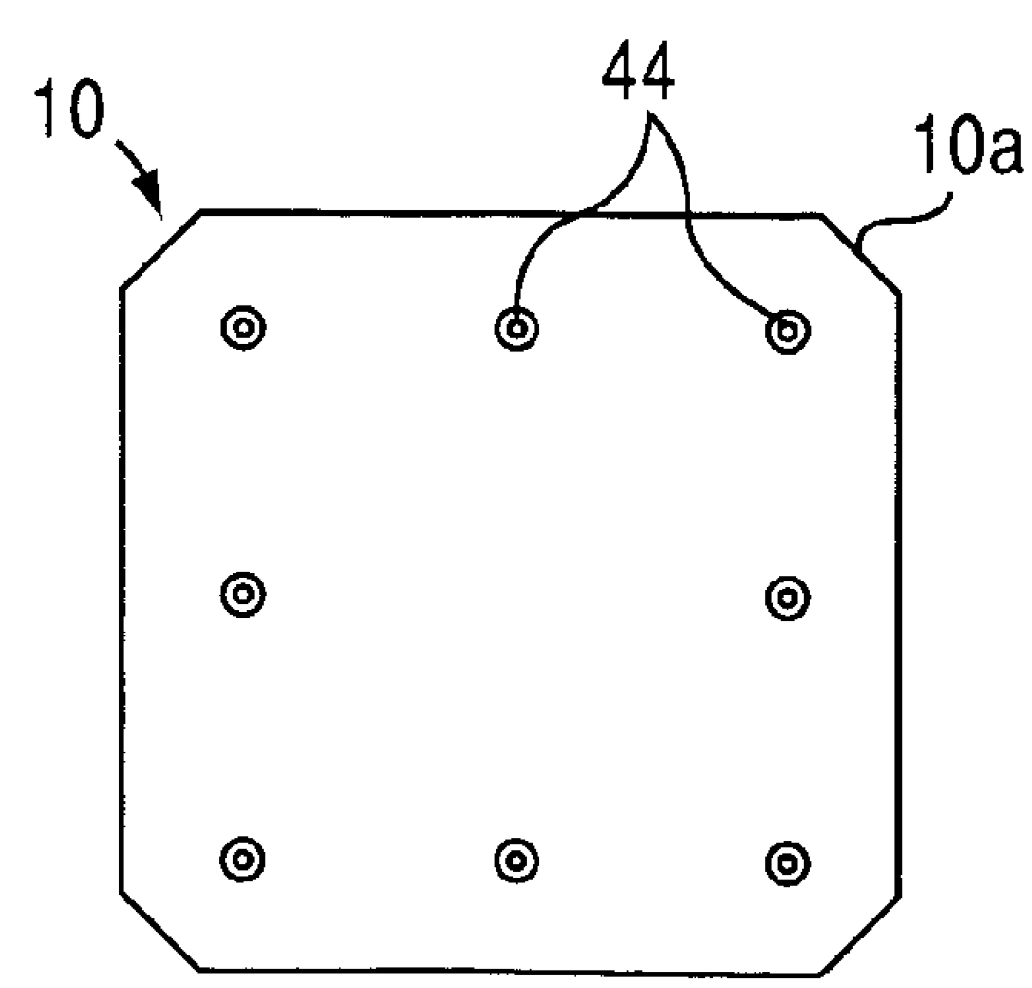


FIG. 17

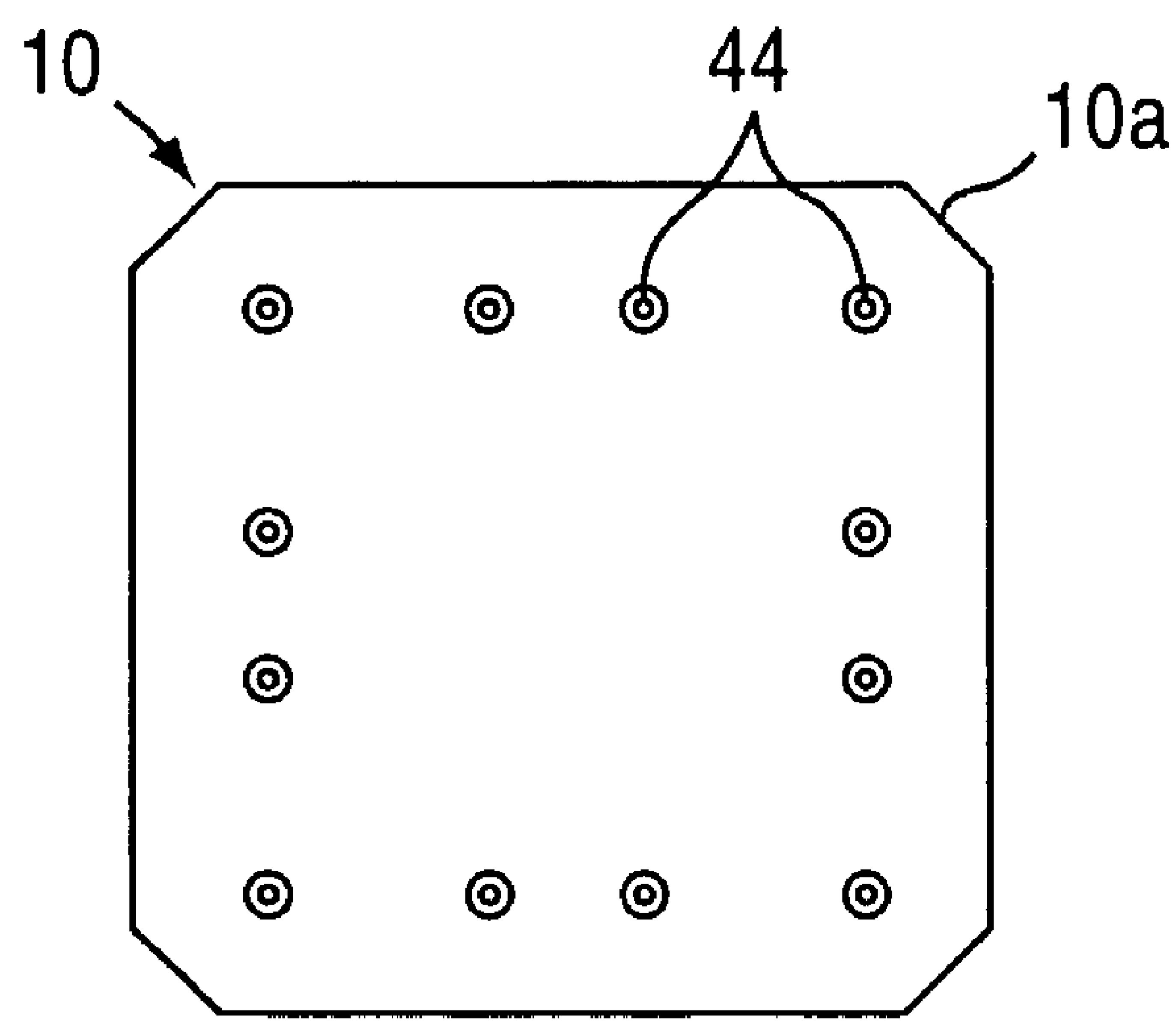


FIG. 18A

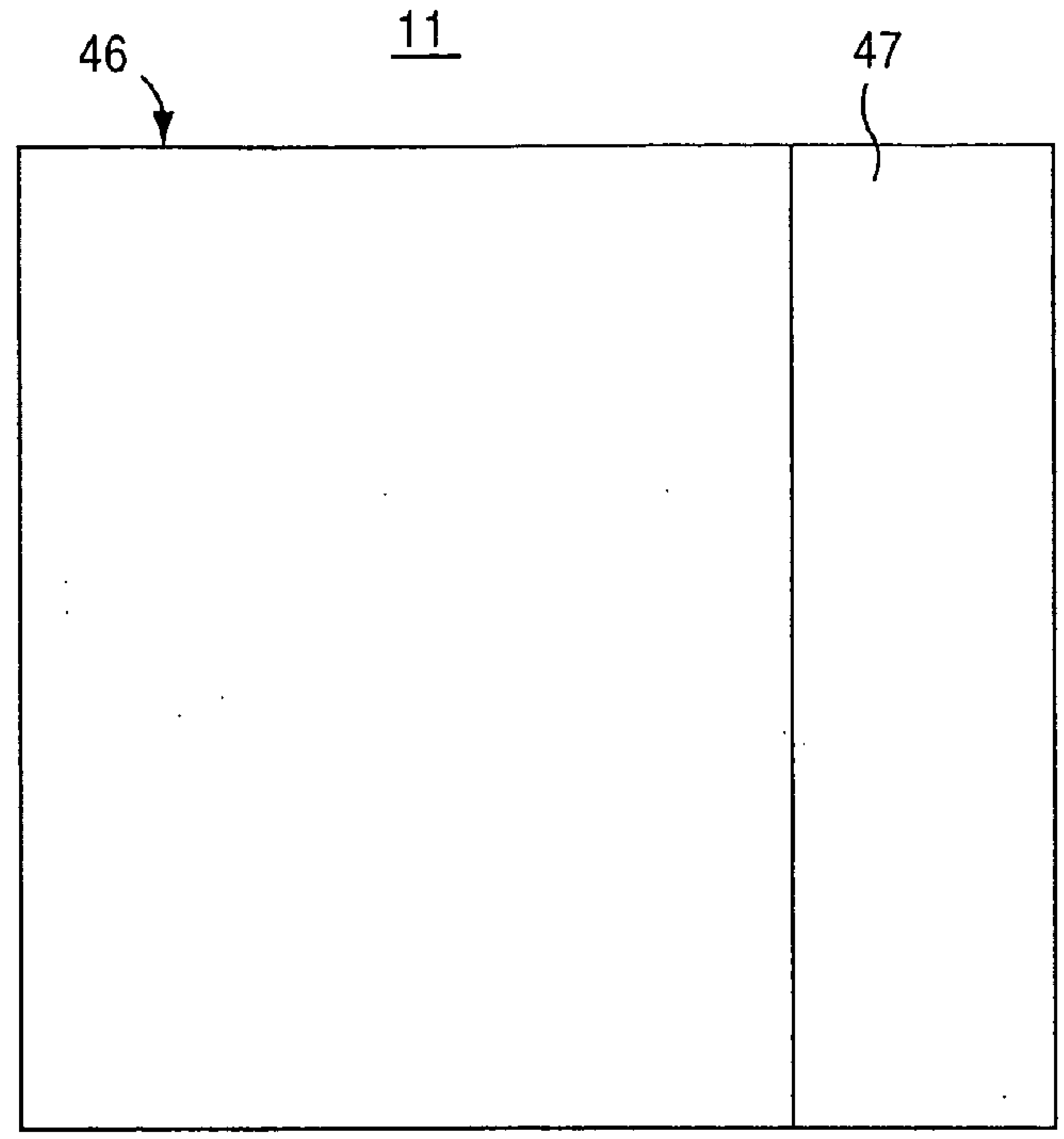


FIG. 18B

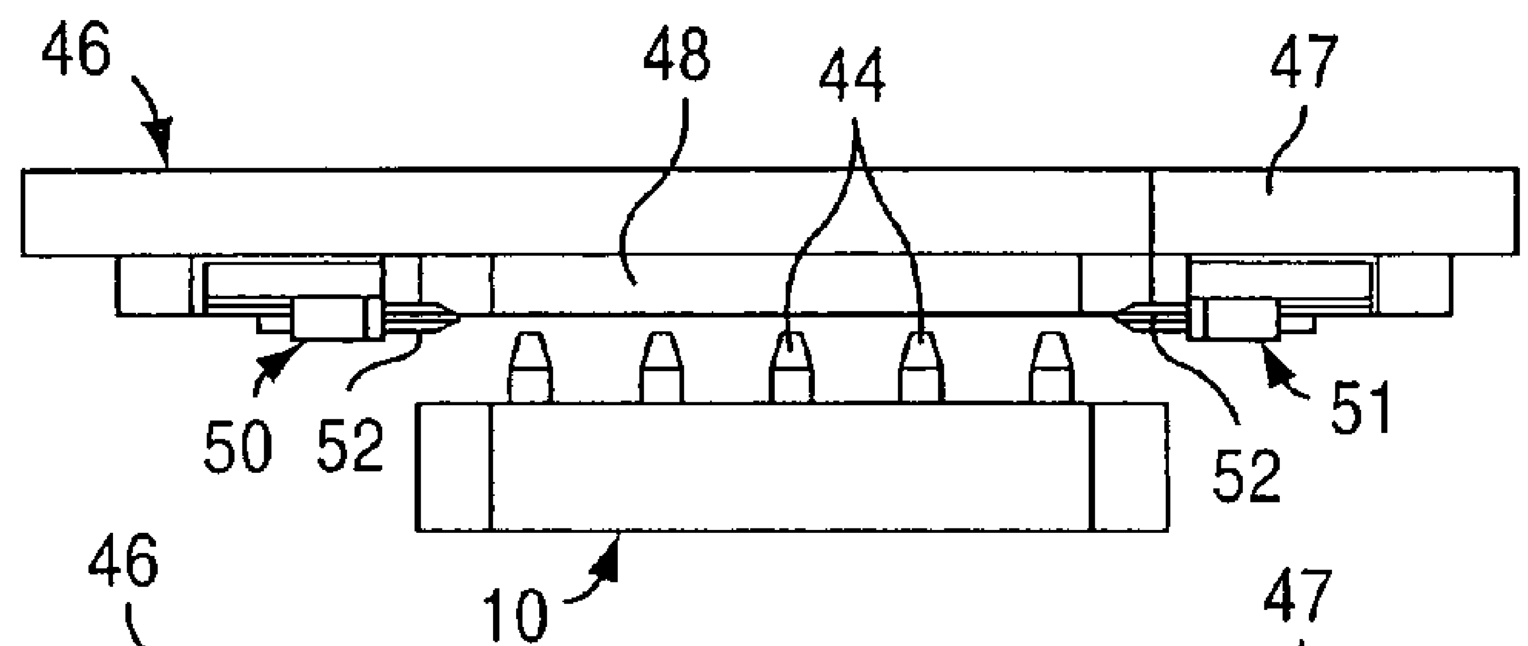


FIG. 18C

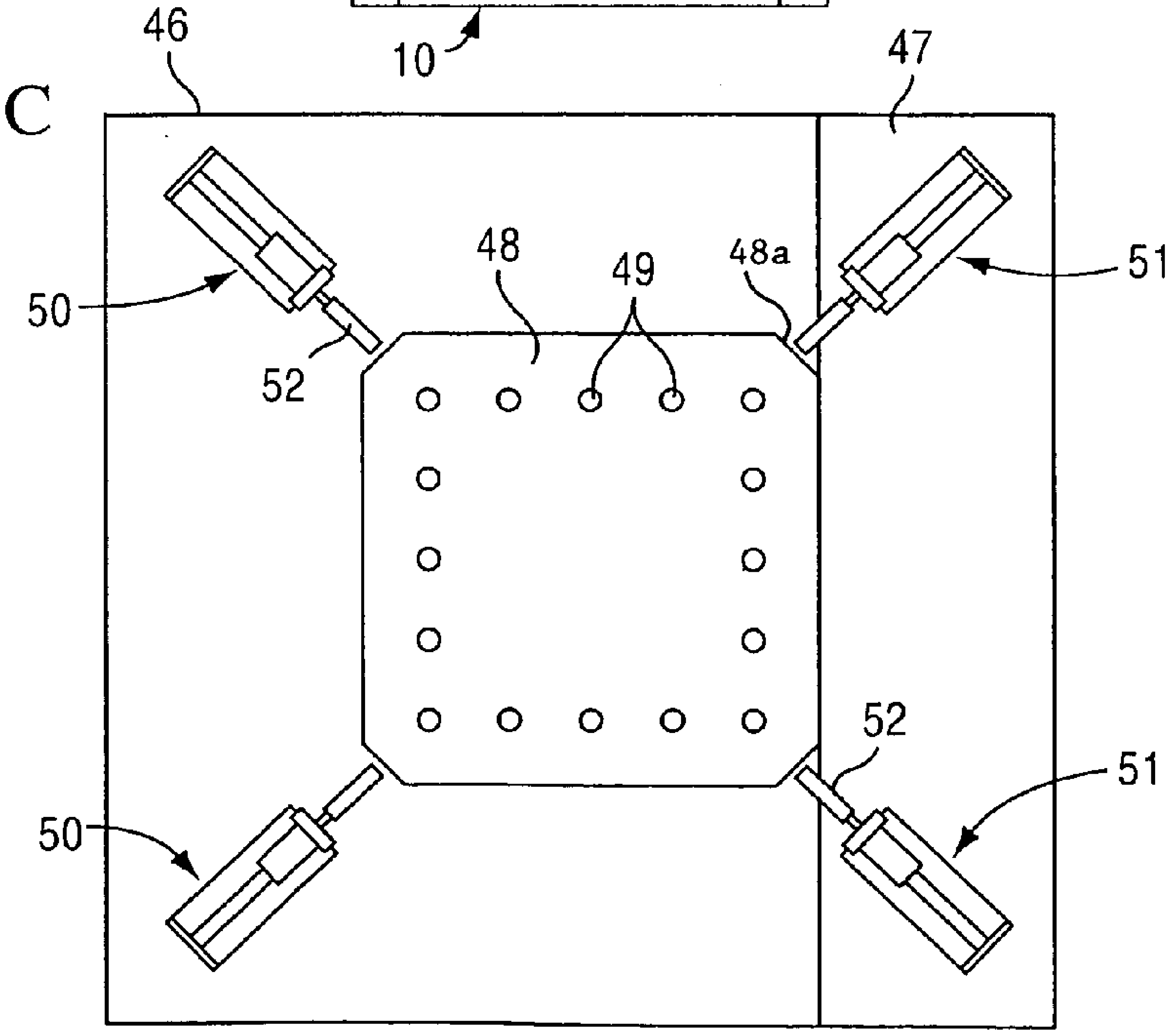


FIG.19A

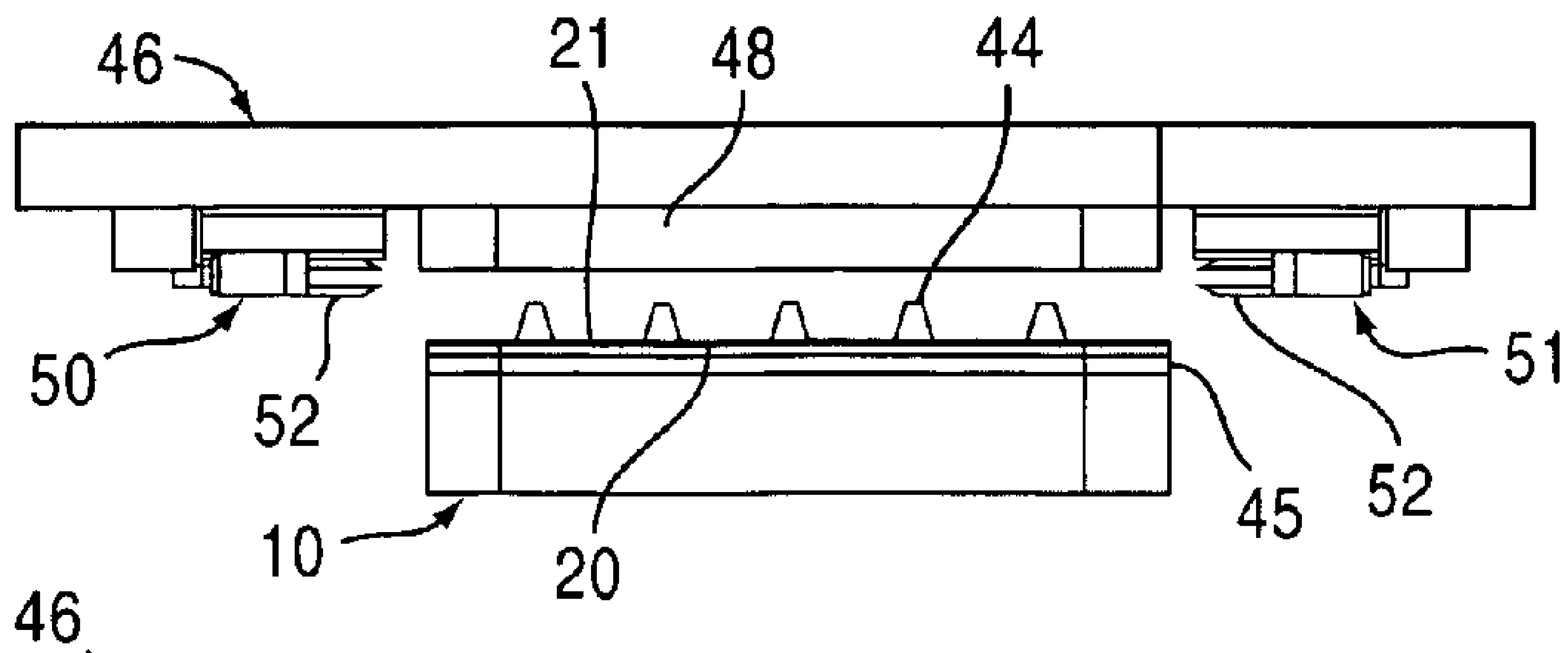


FIG.19B

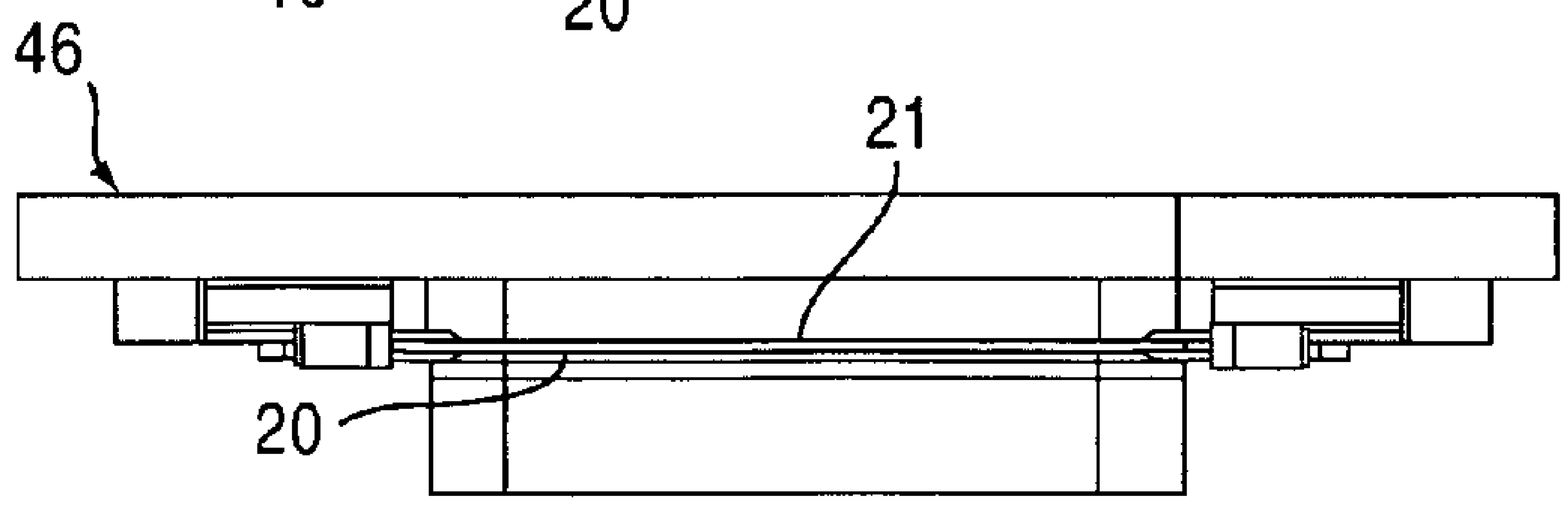


FIG.19C

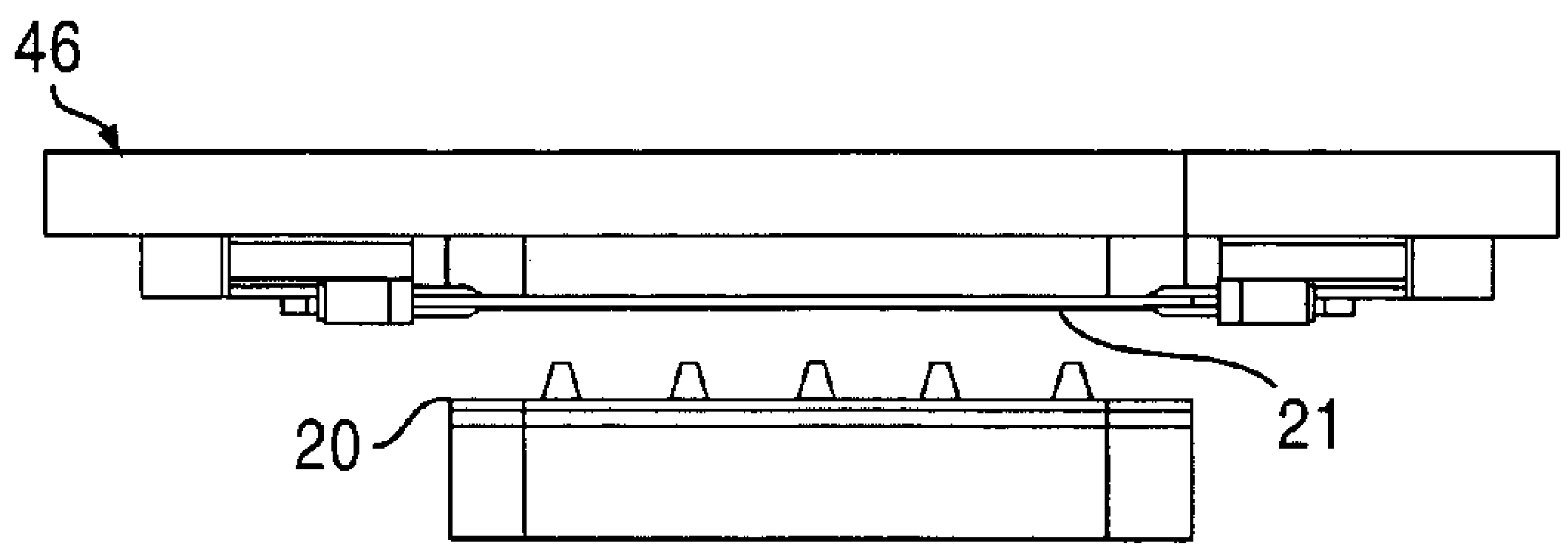


FIG.19D

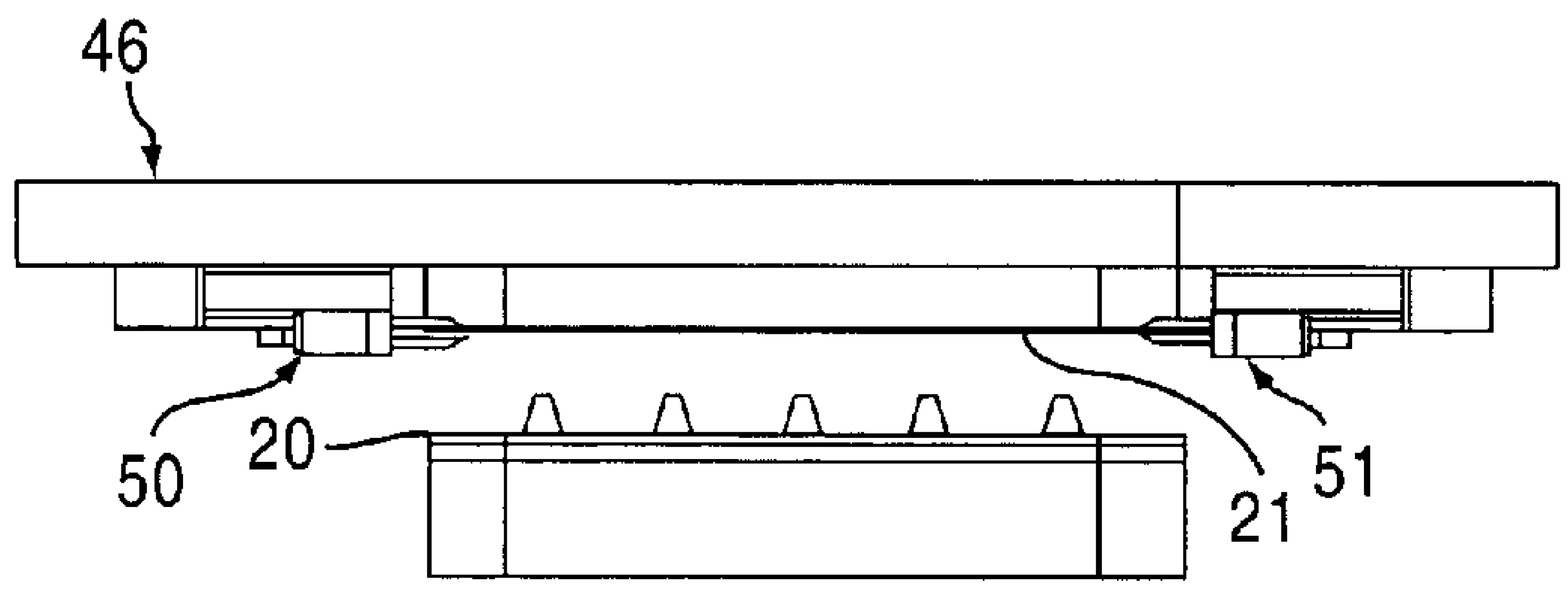


FIG.19E

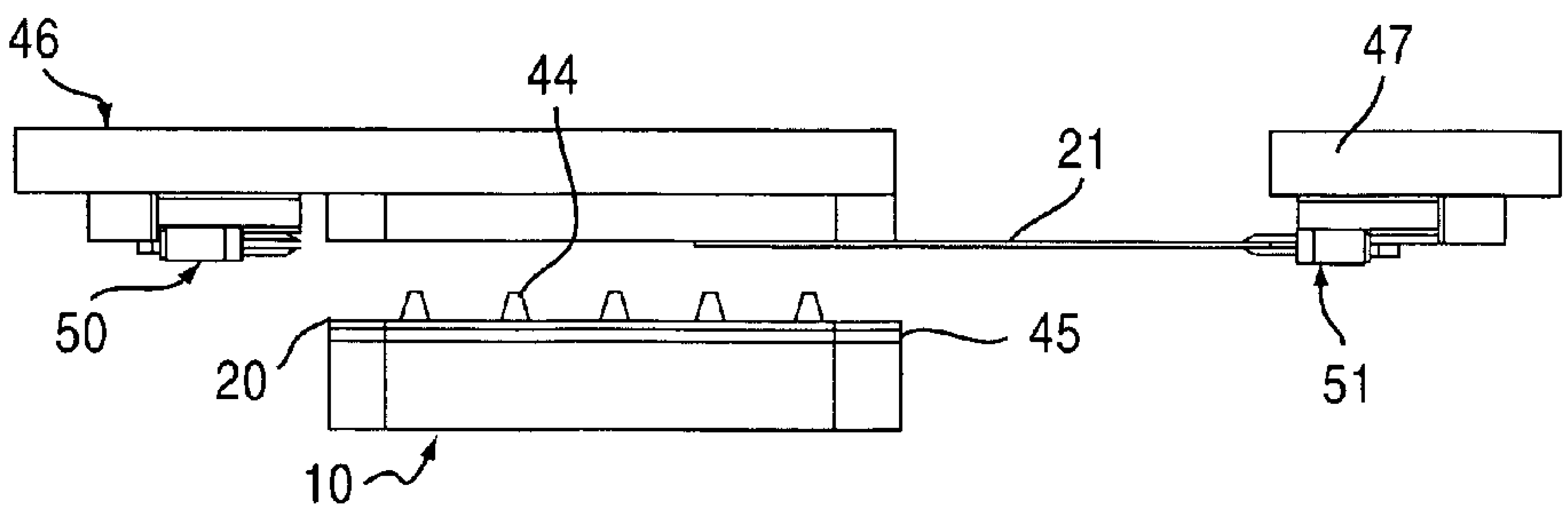


FIG.20

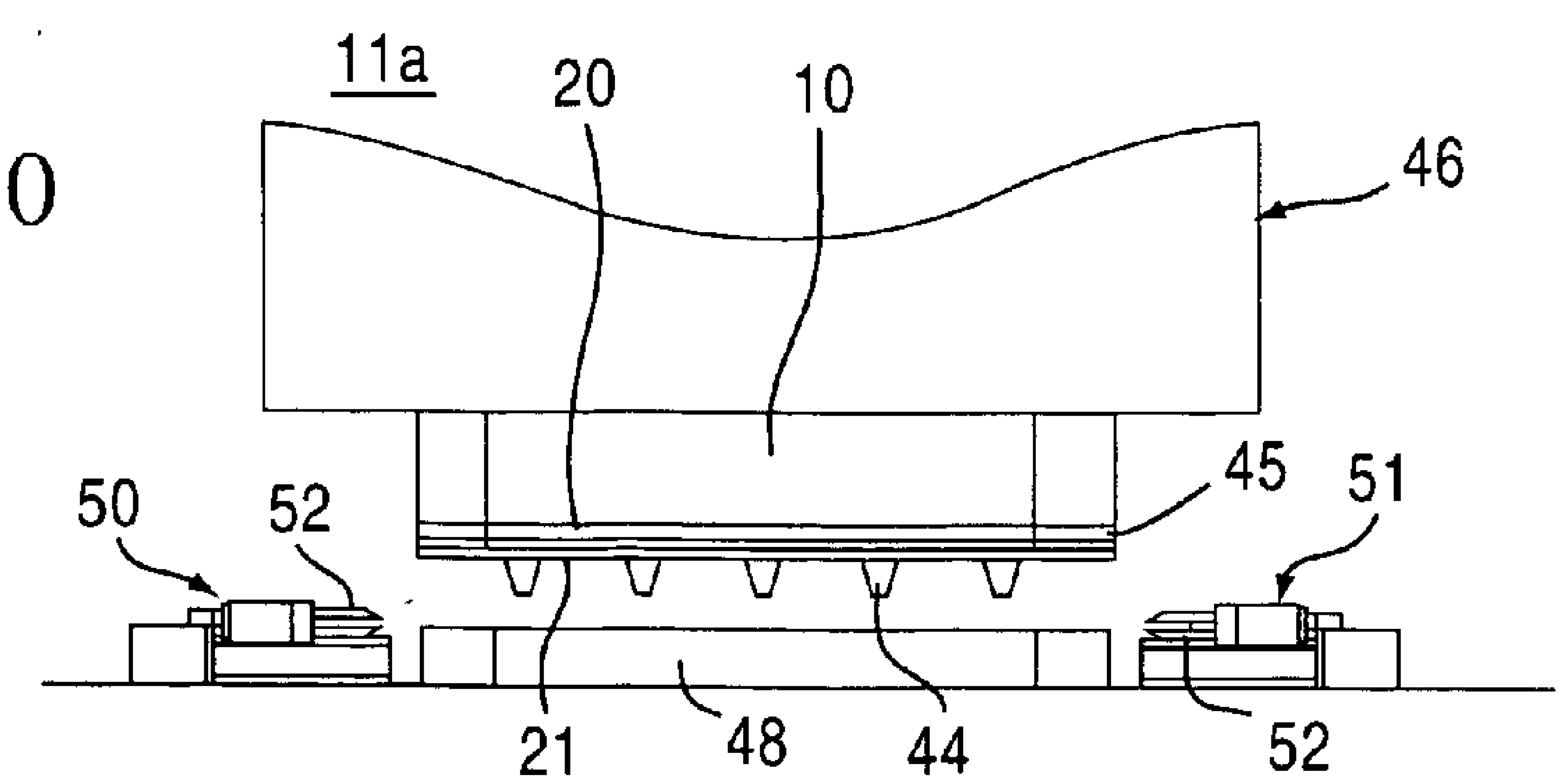


FIG. 21

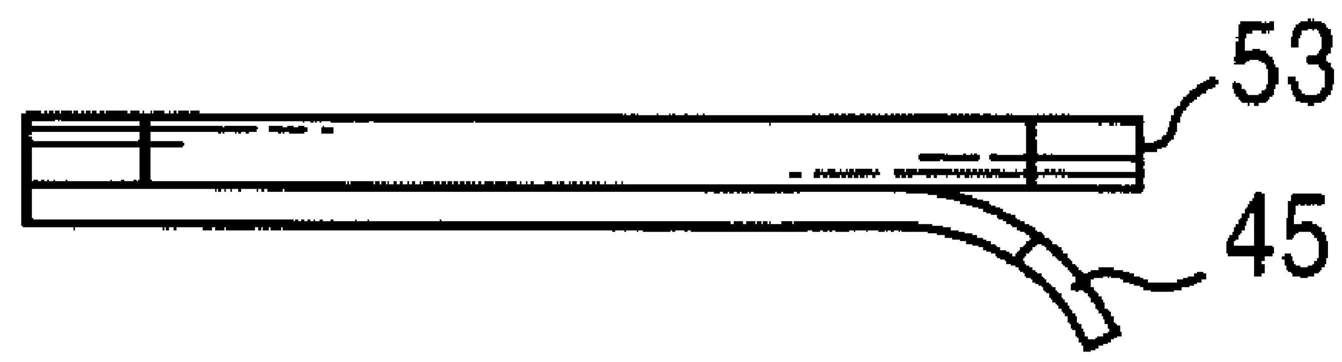
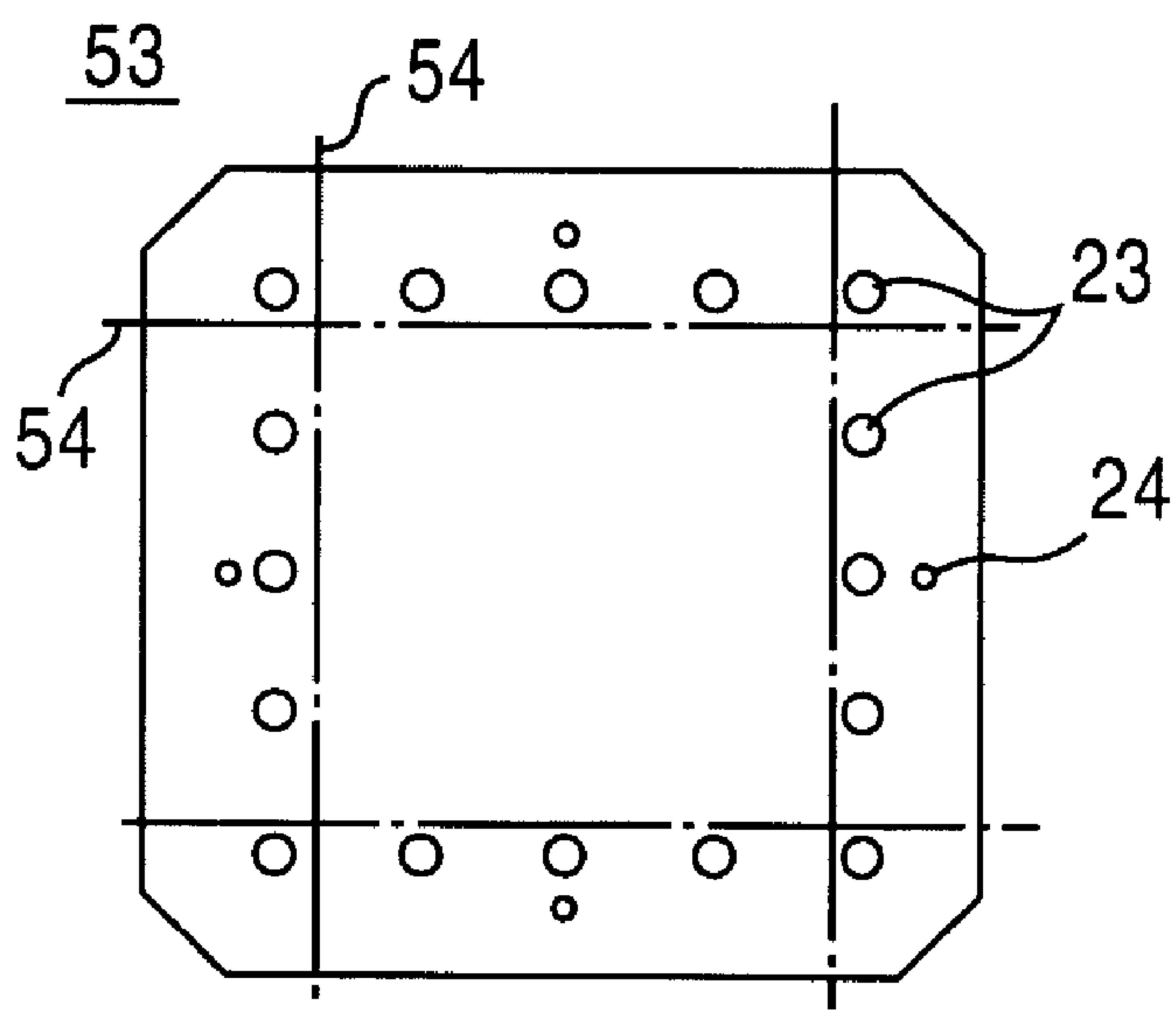


FIG. 22



MANUFACTURING APPARATUS FOR MANUFACTURING ELECTRONIC MONOLITHIC CERAMIC COMPONENTS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to manufacturing apparatuses for manufacturing electronic monolithic ceramic components and, more particularly, to a manufacturing apparatus for manufacturing an electronic monolithic ceramic component having a laminate that is formed by laminating a plurality of ceramic green sheets of a plurality of types in a predetermined order.

2. Description of the Related Art

When electronic monolithic ceramic components such as a multilayer ceramic board, a monolithic ceramic capacitor, and a monolithic ceramic inductor are manufactured, a step of laminating a plurality of ceramic green sheets of a plurality of types in a predetermined order is performed.

The ceramic green sheets laminated in the above-mentioned lamination step are supplied by a sheet supplier which typically sorts, and stacks a plurality of sheets according to the type.

For example, Japanese Unexamined Patent Application Publication No. 9-104016 discloses an apparatus which produces a laminate by supplying a plurality of ceramic green sheets of a desired type from a sheet supplier and by laminating the supplied ceramic green sheets according to a predetermined order.

The sheet supplier in the above-disclosed apparatus sorts ceramic green sheets of a plurality of types according to the type and prepares the ceramic green sheets ready to be supplied, and the plurality of ceramic green sheets is sorted according to the type while being arranged on a planar surface.

For this reason, the utilization efficiency of area in the sheet supplier is low, and the area needed to install a sheet supplier increases to meet the requirement for a diversity of ceramic green sheets to produce a desired electronic monolithic ceramic component.

SUMMARY OF THE INVENTION

The object of the present invention resolves the above-mentioned problem, and it is an object of the present invention to provide a manufacturing apparatus for manufacturing an electronic monolithic ceramic component.

The present invention is directed in one embodiment to a manufacturing apparatus for manufacturing electronic monolithic ceramic components, including a sheet supplier for supplying a plurality of ceramic green sheets of a plurality of types in a predetermined order, and a laminator for laminating the ceramic green sheets supplied by the sheet supplier, and an embodiment of the present invention has the following feature to resolve the above-described problem.

The sheet supplier of the manufacturing apparatus includes a plurality of trays for sorting and holding the plurality of ceramic green sheets of the plurality of types according to the type, and a rack for setting the plurality of trays in a vertical direction in alignment. Each of the trays is drawable from the rack, and each of the trays holds the plurality of ceramic green sheets of the same type stacked one above another.

The manufacturing apparatus further includes a tray drawer device for drawing the plurality of trays according to a predetermined order, and a conveyor device for picking up a single ceramic green sheet from the drawn tray and then conveying the ceramic green sheet to the laminator.

Preferably, the rack is raised and lowered in a vertical direction, and the tray drawer device draws a tray which is positioned at a predetermined height through the upward and downward movement of the rack.

Preferably, the conveyor device includes a chucking device for chucking a topmost ceramic green sheet of the stack of the ceramic green sheets in the tray for conveyance.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a plan view showing the layout of major work areas provided by a manufacturing apparatus **1** for manufacturing electronic monolithic ceramic components in accordance with one embodiment of the present invention;

FIG. **2** is similar to FIG. **1**, and is a plan view showing the general layout of the manufacturing apparatus **1**;

FIG. **3** is a front view generally showing the construction of the manufacturing apparatus **1**;

FIG. **4** is a plan view showing a step for obtaining a ceramic green sheet **20** supplied from the sheet supplier **2** shown in FIG. **1**;

FIG. **5** is a plan view showing a modification of the step for obtaining the ceramic green sheet **20**;

FIG. **6** is a plan view showing via holes **25** and conductive films **27** formed in the ceramic green sheet **20**;

FIG. **7** is a perspective view showing part of a rack **7** arranged in the sheet supplier **2** shown in FIG. **1**;

FIG. **8** is a perspective view of a single tray **8** set in the rack **7** shown in FIG. **7**;

FIG. **9** is a side view showing the operation of a tray drawer device **13** shown in FIG. **2**;

FIG. **10** is a plan view explaining the construction of a corner cutter **3** shown in FIG. **1**;

FIG. **11** is a plan view showing the corner cutter **3** shown in FIG. **10**;

FIGS. **12**A, **12**B, and **12**C are cross-sectional views showing the corner cutting operation of the corner cutter **3** shown in FIG. **10** and FIG. **11**;

FIG. **13** shows the modification of the operation of a cutting edge **36** shown in FIG. **12**;

FIG. **14** is a plan view showing a laminator table **10** shown in FIG. **2**;

FIG. **15** is a front view showing the laminator table **10** shown in FIG. **14**;

FIG. **16** is a plan view showing a first modification of the laminator table **10**;

FIG. **17** is a plan view showing a second modification of the laminator table **10**;

FIGS. **18**A, **18**B, and **18**C show an upper mold **46** arranged in a compression bonder device **11** shown in FIG. **2**, wherein FIG. **18**A is a top view of the upper mold **46**, FIG. **18**B is a front view of the upper mold **46** together with the laminator table **10**, and FIG. **18**C is a bottom view of the upper mold **46**;

FIGS. **19**A–**19**E are a front view showing the operation of the upper mold **46** shown in FIGS. **18**A–**18**C;

FIG. **20** is a front view showing a modification of a compression bonder device;

FIG. **21** is a front view showing the state in which an under sheet **45** is peeled off a laminate **53**; and

FIG. **22** is a plan view showing a step of cutting the peripheral portion of the laminate **53**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** is a plan view showing the layout of major work areas provided by a manufacturing apparatus **1** for manufacturing electronic monolithic ceramic components in accordance with one embodiment of the present invention.

The manufacturing apparatus **1** includes, as the work areas thereof, a sheet supplier **2**, a corner cutter **3**, a laminator **4**, a compression bonder **5**, and a film discharger **6**, and the work areas are arranged as shown in FIG. **1**. Specific jobs carried out in the work areas **2** through **6** will be discussed later.

FIG. **2** is similar to FIG. **1**, and is a plan view showing the general layout of the manufacturing apparatus **1**. FIG. **3** is a front view generally showing the construction of the manufacturing apparatus **1**.

Referring to FIG. **1**, the elements shown in FIG. **2** and FIG. **3** are discussed, and the sheet supplier **2** is provided with a rack **7**. In the rack **7**, a plurality of trays **8** holding ceramic green sheets to be discussed later are arranged in two parallel columns.

The corner cutter **3** includes a corner cutter table **9**.

The laminator **4** includes a laminator table **10**.

The compression bonder **5** includes a compression bonder device **11**.

The film discharger **6** includes a film discharge tray **12**.

A tray drawer device **13** is provided to work with the rack **7**.

To convey the ceramic green sheets, a first chucking device **14** and a second chucking device **15** for chucking the ceramic green sheets through vacuum suction for conveyance are arranged.

The laminator table **10** reciprocatingly moves between the position thereof shown in FIG. **2** and FIG. **3** and the position thereof at the mounting location of the compression bonder device **11**, and rails **16** are arranged to guide the movement of the laminator table **10**.

The tray drawer devices **13** are used to draw the trays **8**, and rails **17** and **18** are arranged to guide such a drawing operation of the tray drawer device **13**. The tray drawer device **13** arranged to work with the rail **18** is not shown in FIG. **2** and FIG. **3**.

The first chucking device **14** reciprocatingly moves between the tray drawer device **13** and the corner cutter table **9**, the second chucking device **15** reciprocatingly moves between the corner cutter table **9** and the laminator table **10**, and a rail **19** is provided to guide the movements of these devices.

FIG. **4** shows ceramic green sheets **20** to be held in the trays **8** set in the rack **7** placed in the sheet supplier **2**.

Referring to FIG. **4**, a carrier film **21** as thick as 50 mm is prepared, and by applying a slurry of ceramic on the carrier film **21**, the ceramic green sheet **20** is produced. To form the ceramic green sheet **20**, a doctor blade method, a die coater method, a roll coater method, etc. may be used.

The thickness of the formed ceramic green sheet **20** falls within a range of 10 mm to 300 mm, and a plurality of types of green sheets **20** having different thicknesses is prepared depending on the design of desired electronic monolithic ceramic components.

The ceramic green sheet **20** lined with the carrier film **21** is stored in a roll, although not shown. The ceramic green sheet **20** is paid out from the roll, and is cut along a cut line **22** together with the carrier film **21** to a size of 150 mm by 150 mm, for example.

The ceramic green sheet **20** thus cut to the predetermined dimensions as described above has a plurality of pin insertion holes **23** and a plurality of reference holes **24**, which also penetrate the carrier film **21**. The pin insertion holes **23** and the reference holes **24** are concurrently opened using a die or a laser. In this way, no positional deviation takes place between the pin insertion holes **23** and the reference holes **24**.

The pin insertion holes **23**, each having a diameter of 3 to 5 mm, are opened on the peripheral portion of the rectangularly cut ceramic green sheet **20**, specifically, at each corner and in the edge portion near the four sides of the ceramic green sheet **20**. In this embodiment, five pin insertion holes **23** are arranged along each side of the ceramic green sheet **20** within an inward area of 3 to 7 mm from each side of the ceramic green sheet **20**.

The reference holes **24**, each having a size of 1 mm, are opened with one at the center of each edge portion near each side of the rectangularly cut ceramic green sheet **20**.

In the step described with reference to FIG. **4**, the pin insertion holes **23** and the reference holes **24** are opened after cutting the ceramic green sheet, but alternatively, as shown in FIG. **5**, the pin insertion holes **23** and the reference holes **24** may be opened in the ceramic green sheet **20** paid out from the roll and then the ceramic green sheet **20** may be cut to the predetermined dimensions. As shown in FIG. **5**, elements identical to those with reference to FIG. **4** are designated with the same reference numerals and the discussion thereof is not repeated.

FIG. **6** shows a ceramic green sheet **20** cut to the predetermined dimensions. The ceramic green sheet **20** is then subjected to several processes depending on the design of a desired electronic monolithic ceramic component.

Referring to FIG. **6**, via holes **25** are opened and then filled with an electrically conductive paste **26**, and a conductive film **27** having a predetermined pattern is formed by printing an electrically conductive paste. The filling of the via holes **25** with the electrically conductive paste and the formation of the conductive film **27** may be performed at the same step or may be performed at different steps.

The electrically conductive paste **26** filling the via holes **25** and the electrically conductive paste for the conductive film **27** contain copper, nickel, and silver, or silver and palladium as an electrically conductive material.

A laser or a die is used to open the via holes **25**.

To fill the via holes **25** with the electrically conductive paste **26**, the electrically conductive paste **26** is preferably applied with the via holes **25** kept in a negative pressure state, and the application of the electrically conductive paste **26** may be performed on the side of the carrier film **21** with a mask applied on the carrier film **21** or may be performed on the side of the ceramic green sheet **20** using screen printing technique.

A CCD camera monitors the formation of the via holes **25**, the filling of the via holes **25** with the electrically conductive paste **26**, and the formation of the conductive film **27** by sensing the reference holes **24** and using the reference holes **24** as a position reference.

There are some ceramic green sheets **20** having a conductive film only, and other ceramic green sheets **20** having via holes filled with no electrically conductive paste. Some ceramic green sheets **20** have neither conductive film nor via holes.

The ceramic green sheets **20** subjected to the above-described processes are sorted according to the type of process and the thickness thereof, and are placed into the respective trays **8** as shown in FIG. **7** and FIG. **8**, and the trays **8** are set in vertical columns in the rack **7**. As already discussed, a plurality of trays **8** is vertically set in two columns in the rack **7** as best seen from FIG. **7**.

The rack **7** is housed in a frame **28**, and is vertically raised and lowered using a lift mechanism (not shown). With the rack **7** raised and lowered, a particular tray **8** is moved to a predetermined level. Each of the trays **8** holds a plurality of ceramic green sheets **20** of the same type. By laminating ceramic green sheets held in a plurality of trays **8** in a predetermined order, a laminate of a desired electronic monolithic ceramic component is produced.

Referring to FIG. **7**, the utilization efficiency of area is increased by setting a plurality of trays **8** in the rack **7**, and without the need for increasing the area of the sheet supplier, the manufacturing apparatus handles a diversity of ceramic green sheets **20** to produce a desired electronic monolithic ceramic component.

In the embodiment shown, the plurality of trays **8** is arranged in two columns in the rack **7**, but the number of columns may be one or may be three in the rack **7**.

To pick up a desired ceramic green sheet **20**, the tray drawer device **13** draws a particular tray **8** holding a desired ceramic green sheet **20** as shown in FIG. **7**. FIG. **9** shows the tray drawer device **13** in detail.

Referring to FIG. **9**, the rack **7** is raised or lowered by drive **125** as represented by an arrow **29** to a level as high as the tray drawer device **13**. A chuck **32** travels along a rail **31** that extends in a direction represented by an arrow **30**, and at one end of the travel, the chuck **32** is raised in a direction represented by an arrow **33**, and pins provided on the end of the chuck **32** are mated with the tray **8**. In succession, the chuck **32** travels in an opposite direction along the rail **31**, thereby drawing the tray **8**.

In this state, the previously-mentioned first chucking device **14** vacuum-chucks the topmost ceramic green sheet **20** in the tray **8** to convey it to the corner cutter table **9**.

A ceramic green sheet **20** immediately beneath the topmost ceramic green sheet **20** vacuum-chucked by the first chucking device **14** may electrostatically adhere to the topmost ceramic green sheet **20**, and that second ceramic sheet **20** may also be picked up together. To prevent this, the first chucking device **14** has preferably the following construction.

The chucking device **14** vacuum-chucks the ceramic green sheet **20** near opposed edges of the ceramic green sheet **20** and temporarily places the chucking points closer to each other at the moment of lifting the ceramic green sheet **20** to cause the ceramic green sheet **20** to sag. The sagging ceramic green sheet **20** forces the ceramic green sheet **20** therebeneath to separate therefrom.

After the first chucking device **14** picks up the ceramic green sheet **20**, the chuck **32** travels along the rail **31** to put the tray **8** back to the rack **7**. The first chucking device **14** lowers the chuck **32** in the direction represented by the arrow **33**, disengages a lock pin **34** from a locking state thereof, and moves along the rail **31** out of the rack **7** to be on standby.

On standby, the first chucking device **14** is ready to start an operation to draw a next tray **8**, and the time required to pick up the ceramic green sheet **20** is thus shortened.

As described above, the tray **8** is put back into the rack **7** after the desired ceramic green sheet **20** is picked up, and no tray is placed below the conveyance path of the first chucking device **14**, and this arrangement reduces the possibility that the ceramic green sheet **20** in the tray **8** is contaminated with dirt falling in the course of conveyance.

In this embodiment, the ceramic green sheet **20** lined with the carrier film **21** is handled with the carrier film **21** facing upward. Referring to FIG. **7** and FIG. **8**, each of the ceramic green sheets **20** held in the tray **8** is thus covered with the carrier film **21**.

When the ceramic green sheet **20** is picked up, a processor unit P (shown schematically in FIG. **1**) stores beforehand data concerning the types of, the lamination order of, and the number of ceramic green sheets **20** required to produce a laminate of a desired electronic monolithic ceramic component, and the processor thereby causes the tray **8** holding a required ceramic green sheet **20** to be drawn, and the first chucking device **14** to pick up the ceramic green sheets **20** one by one.

FIG. **10** and FIG. **11** show the corner cutter **3** of FIG. **1**. FIG. **10** and FIG. **11** also show the corner cutter table **9** of FIG. **2** and FIG. **3**.

The corner cutter **3** cuts and removes the four corners of the ceramic green sheet **20** lined with the carrier film **21**. As a result, the carrier film **21** only remains at the four corners. The four corners of the carrier film **21** enable the carrier film **21** only to be gripped, and the carrier film **21** is thus peeled off the ceramic green sheet **20** by picking the carrier film **21** only in a peel step to be discussed later.

Pressure plates **35** are arranged above the corner cutter table **9**. The pressure plates **35** are movable upward and downward. When moving downward, the pressure plates **35** press the ceramic green sheet **20** downward against the corner cutter table **9**.

The corner cutter table **9** on the four corners thereof are cut away, forming bevels **9***a*, and a cutting edge **36** is arranged to be aligned with the bevel **9***a*. The operation of the cutting edge **36** is shown in FIGS. **12**A, **12**B, and **12**C.

When the cutting edge **36** is raised, only the ceramic green sheet **20** at the four corners thereof are cut with the carrier film **21** remaining intact as shown in FIG. **12**A.

Referring to FIG. **12**B, the cutting edge **36** laterally slides in a direction represented by an arrow **37**, thereby removing each corner **38** from the ceramic green sheet **20**. As a result, the carrier film **21** extends at the four corners thereof.

Referring to FIG. **12**C, the cutting edge **36** is placed back to the original position thereof.

Referring to FIG. **13**, the cutting edge **36** may be pivoted or swung about a predetermined pivotal point in a direction represented by an arrow **39**.

The corner cutter **3** checks to see if the ceramic green sheet **20** mounted on the corner cutter table **9** needs laminating. For this reason, each ceramic green sheet **20** bears a mark indicating the type thereof. For example, such a mark is shown in a bar code. The bar code is printed at the same time as the previously-mentioned conductive film **27**.

A bar code reader **40** is arranged below the corner cutter table **9** to read the bar code, and the corner cutter table **9** has a window **41** where the bar code comes to.

Instead of the bar code, or in cooperation with the bar code, a plurality of punched holes arranged in a code may be opened in the ceramic green sheet **20**. The holes may be opened together with the previously-mentioned via holes **25** when the via holes **25** are opened. The punched holes may be monitored by a camera, for example.

In this embodiment, the thickness of the ceramic green sheet **20** placed on the corner cutter table **9** is checked. As shown in FIG. **11**, a contact type dial gauge **42** is arranged above the corner cutter table **9**. The dial gauge **42** measures the thickness of the ceramic green sheet **20** on the corner cutter table **9** by touching a measuring probe **43** to the ceramic green sheet **20**, or more exactly, to the carrier film **21** on the corner cutter table **9**.

The main purpose of the thickness measurement is to see if a plurality of ceramic green sheets **20** happens to be picked up by the first chucking device **14** from the tray **8** and happens to be undesirably stacked on the corner cutter table **9**.

The thickness measurement may be performed using a non-contact type measurement device such as a laser displacement device.

When the bar code or the punched holes on the ceramic green sheet **20** indicating the type thereof are inappropriate, or when the thickness of the ceramic green sheet **20** is inappropriate, the ceramic green sheet **20** is removed from the corner cutter table **9**.

The reading of the bar code or the punched holes and thickness measurement by the dial gauge **42** may be performed substantially in parallel or sequentially one after the other.

In this embodiment, the comers of the ceramic green sheet **20** are cut on the corner cutter table **9** subsequent to the checking of the ceramic green sheet **20**, but alternatively, the checking step for the ceramic green sheet **20** may be performed in a place other than the corner cutter **3**, and thereafter only the ceramic green sheets **20** that have passed the check may be conveyed to the corner cutter **3**.

The ceramic green sheet **20** having undergone corner cutting on the corner cutter table **9** is transported on the laminator table **10** by the second chucking device **15** as already discussed.

The previously-mentioned first chucking device **14** may be used to transport the ceramic green sheet **20** from the corner cutter table **9** to the laminator table **10** with the second chucking device **15** dispensed with.

FIG. **14** and FIG. **15** are respectively a plan view and a front view of the laminator table **10**.

The laminator table **10** has bevels **10***a* with the four corners cut away. A plurality of guide pins **44** are arranged on the laminator table **10**. The guide pins **44** are to be respectively inserted into the pin insertion holes **23** opened in the ceramic green sheet **20**, and have the same layout as that of the pin insertion holes **23**.

The diameter of the guide pin **44** is substantially equal to the diameter of the pin insertion hole **23**, and as already discussed, when the diameter of the pin insertion hole **23** is 3 to 5 mm, the diameter of the guide pin is also 3 to 5 mm. If the guide pin **44** is substantially smaller in diameter than the pin insertion hole **23**, the alignment accuracy of the ceramic green sheet **20** is degraded, and conversely, if the guide pin **44** is larger in diameter than the pin insertion hole **23**, the guide pin **44** cannot be inserted into the pin insertion hole **23**, and an insertion attempt of the guide pin **44** may damage the ceramic green sheet **20** in the vicinity of the pin insertion hole **23**.

Each of the guide pins **44** is preferably tapered toward the end thereof.

Since the guide pins **44** are supported in such a manner as to move upward and downward relative to the laminator table **10**, the guide pins **44** take the projected state thereof as shown in FIG. **15** and the unshown retracted state thereof.

When a plurality of ceramic green sheets **20** is laminated on the laminator table **10**, an under sheet **45** not shown in FIG. **4** and FIG. **5** is preferably arranged on and in contact with the laminator table **10**. The under sheet **45** is shown in FIG. **19**A–**19**E, FIG. **21** and other figures. The under sheet **45** is fabricated of a plastic sheet having a surface roughness, for example.

The laminator table **10** preferably has a means for fixing the under sheet **45** thereon. The under sheet **45** is fixed on the laminator table **10** using an adhesive means, vacuum chucking, or a mechanical means.

When the under sheet **45** is fixed on the laminator table **10** through vacuum chucking, a plurality of suction holes is opened in the laminator table **10**, and the under sheet **45** is vacuum-chucked onto the laminator table **10**. The cross-sectional shape of the suction hole may be discretionary, and has preferably a diameter within a range from 0.4 to 1.0 mm. If the diameter is smaller than 0.4 mm, a machining process for drilling the suction hole becomes difficult, and resulting chucking power is not sufficient, and if the diameter is larger than 1.00 mm, the suction hole print remains on the ceramic green sheet **20**, making the ceramic green sheet **20** aesthetically unacceptable or damaging the ceramic green sheet **20** in extreme cases.

The layout of the guide pins **44** in the laminator table **10** is determined to be in alignment with the layout of the pin insertion holes **23** in the ceramic green sheet **20**, and when the layout of the pin insertion holes **23** is modified as shown in FIG. **16** or FIG. **17**, the guide pins **44** are arranged accordingly in the laminator table **10**.

Referring to FIG. **16**, the guide pins **44** are arranged with one at each of the four corners and with one at the center of the edge portion of each side, and as a result, three guide pins **44** are arranged at each side of the laminator table **10**.

Referring to FIG. **17**, the guide pins **44** are arranged with one at each of the four corners and with two offset to the center of the edge portion of each side, and as a result, four guide pins **44** are arranged.

The guide pins **44** are arranged in such a manner as to prevent the ceramic green sheet **20** from being deformed in a compression bonding step to be discussed later.

As already discussed, the ceramic green sheet **20** that has undergone the corner cutting step in the corner cutter **3** is then conveyed to the laminator **4** by the second chucking device **15**, and is then laminated on the under sheet **45** on the laminator table **10**. Each time the laminator **4** completes lamination, the laminator table **10** is moved along the rails **16** to a position below the compression bonder device **11** of the compression bonder **5**.

Referring to FIGS. **18**A–**18**C, there is shown an upper mold **46** provided in the compression bonder device **11** of the compression bonder **5**. FIG. **18**A is a top view of the upper mold **46**, and FIG. **18**B is a front view of the upper mold **46** together with the laminator table **10**, and FIG. **18**C is a bottom view of the upper mold **46**.

The upper mold **46** is generally driven in a vertical direction. A portion of the upper mold **46** constitutes a movable section **47**, which is laterally movable to be separated from the rest of the upper mold **46**.

Provided on the underside of the upper mold **46** is a compression bonding member **48** having a compression bonding surface. Referring to FIG. **18**C, the compression bonding member **48**, with a planar shape substantially identical to that of the laminator table **10**, has bevels **48***a* with the four corners thereof cut away. The compression bonding member **48** has on the compression bonding surface thereof relief holes **49** that receive the guide pins **44** projecting from the laminator table **10**.

Provided on the underside of the upper mold **46** are gripping mechanisms **50** and **51** facing the respective bevels **48***a* of the four corner of the compression bonding member **48**. The gripping mechanisms **51** out of the gripping mechanisms **50** and **51** are arranged on the movable section **47**.

The gripping mechanisms **50** and **51** are substantially identical to each other in structure, and respectively include chucks **52** for gripping the corners of the carrier film **21**, and the chuck **52** is openable and closable to release or to grip the carrier film **21**, and is movable in diagonal lines to approach and go away from the compression bonding member **48**.

FIGS. **19**A-**19**E show the operation of the upper mold **46** of the compression bonder device **11**.

FIG. **19**A shows the laminator table **10** in its position shifted below the upper mold **46**. The ceramic green sheet **20** having predetermined dimensions and lined with the carrier film **21** is placed on the under sheet **45** on the laminator table **10**. The ceramic green sheet **20** and the carrier film **21** are aligned with the laminator table **10** with the guide pins **44** received by the pin insertion holes **23**. The ceramic green sheet **20** has no corners because it has undergone the corner cutting step in the corner cutter **3**.

Referring to FIG. **19**B, the upper mold **46** is lowered, and the compression bonding member **48** presses the ceramic green sheet **20**. The chucks **52** of the respective gripping mechanisms **50** and **51** move in such a manner to receive the corners of the carrier film **21** and then close themselves to grip the corners of the carrier film **21**.

Referring to FIG. **19**C, the upper mold **46** is raised. Since the chucks **52** of the respective gripping mechanisms **50** and **51** grip the corners of the carrier film **21**, the carrier film **21** is peeled off the ceramic green sheet **20** as the upper mold **46** is raised.

Referring to FIG. **19**D, the chucks **52** of the gripping mechanisms **50** are opened to release the carrier film **21**. On the other hands, the chucks **52** of the gripping mechanisms **51** continuously grip the carrier film **21**.

Referring to FIG. **19**E, the movable section **47** laterally moves with the chucks **52** of the gripping mechanisms **51** continuously gripping the carrier film **21**. At the end of the travel, the carrier film **21** is positioned above the film discharge tray **12** arranged in the film discharger **6** shown in FIG. **1** through FIG. **3**. At the end of the travel, the chucks **52** of the gripping mechanisms **51** are then opened, releasing the carrier film **21** into the film discharge tray **12**.

The laminator table **10** is then moved back to the laminator **4** as shown in FIG. **1** to be on standby for laminating a next ceramic green sheet **20**.

The process from the picking of the ceramic green sheet **20** from the tray **8** to the compression bonding of the ceramic green sheet **20** to the peeling of the carrier film **21** as discussed above is repeated until a desired electronic monolithic ceramic component is produced.

In the above-described compression bonding step, the ceramic green sheet **20** is preferably heated to a temperature within a range from 40 to 100° C.

Further, in the compression bonding step, the ceramic green sheet **20** is put under a pressure within a range from 200 to 350 Kg/cm^2. In this case, conditions applied on the ceramic green sheet **20**, such as compression time and pressure, may be modified depending on the types and quantities of a ceramic material and a binder contained in the ceramic green sheet **20**, the peel property of the carrier film **21**, the area of the conductive film **27** formed on the ceramic green sheet **20**, and the lamination order of a current ceramic green sheet **20** among all layers.

FIG. **20** shows a modification of the compression bonder device. As shown in FIG. **20**, elements identical to those described with reference to FIGS. **18**A-**18**C and FIGS. **19**A-**19**E are designated with the same reference numerals, and the discussion thereof is not repeated.

The compression bonder device **11**a shown in FIG. **20** has a topside down version of the compression bonder device **11**. Specifically, the upper mold **46** holds the laminator table **10**, and arranged below the laminator table **10** are the compression bonding member **48** and the gripping mechanisms **50** and **51**.

As discussed above, when lamination of the ceramic green sheet **20** required to produce a laminate is completed, the laminate **53** (see FIG. **21** or FIG. **22**) is taken out together with the under sheet **45**. When the laminate **53** is picked up, the guide pins **44** arranged on the laminator table **10** are lowered for retraction. This is intended to prevent the guide pins **44** from erratically interfering with the laminate **53** when the laminate **53** is discharged.

The discharged laminate **53** with the under sheet **45** attached thereto is cooled to room temperature, and then the under sheet **45** is peeled off as shown in FIG. **21**. In this way, the laminate **53** is protected from unwanted stretch or deformation.

Referring to FIG. **22**, the laminate **53** is diced along cut lines **54** to remove areas including the pin insertion holes **23** and the reference holes **24** therewithin. In a press step to be performed later, this dicing step prevents the laminate **53** from being stretched or deformed by the presence of the pin insertion holes **23** and the reference holes **24**.

The laminate **53** is then placed on a press die assembly composed of an upper punch and a lower notched die, although not shown, and then a press step using a rigid-body press is performed on the laminate **53**, thereby pressing the laminate **53** in the direction of lamination.

By increasing the pressure applied in the compression bonding step, the press step may be skipped.

The laminate **53** is diced by a dicing saw or a cutting edge to obtain a laminate chip for individual electronic monolithic ceramic components.

The laminate chip is then sintered. External surfaces, for example, end faces of the sintered laminate chip are coated with an electrically conductive paste including an electrically conductive component such as copper, silver, nickel, or the like, and is then dried, and baked to form external electrodes. The external electrodes are then plated with nickel and/or tin, as necessary.

To form the external electrode, an electrically conductive paste may be applied on the laminate chip prior to sintering, and baking for forming external electrodes may be performed concurrently with the sintering of the laminate chip. In this case, the electrically conductive paste for forming the external electrodes is preferably fabricated of an electrically conductive paste containing substantially the same component as that for the electrically conductive paste **26** filling the previously-referenced via holes **25** and the electrically conductive paste forming the conductive film **27**.

In this way, a desired electrical monolithic ceramic component is manufactured.

As described above, to manufacture electronic monolithic ceramic components, a sheet supplier for supplying a plurality of ceramic green sheets of a plurality of types in a predetermined order to a laminator for laminating the ceramic green sheets includes a plurality of trays for sorting and holding the plurality of ceramic green sheets of the plurality of types according to the type, and a rack for setting the plurality of trays in a vertical direction in alignment, and for this reason, the utilization efficiency of area in the sheet supplier is high, and the manufacturing apparatus handles a diversity of ceramic green sheets to produce a desired electronic monolithic ceramic component.

In accordance with this invention, each of the trays can be drawn from the rack, and the manufacturing apparatus further includes the tray drawer device for drawing the plurality of trays according to a predetermined order, and a conveyor device for picking up a single ceramic green sheet from the drawn tray and then conveying the ceramic green sheet to the laminator, and thus after a desired ceramic green sheet is picked up, the tray is placed in the rack. Since the tray is placed in the rack during the conveyance of the ceramic green sheet by the conveyor device, there is a low possibility that the ceramic green sheet in the tray is contaminated with dirt falling in the course of conveyance.

In accordance with the present invention, the rack is raised and lowered in a vertical direction, and the tray drawer device draws a tray which is positioned at a predetermined height through the upward and downward movement of the rack, and the tray drawer device is thus operated at the predetermined height, and components associated with the tray drawer device are of a simple construction.

In accordance with the present invention, the conveyor device includes a chucking device for chucking a topmost ceramic green sheet of the stack in the tray for conveyance, and a single ceramic green sheet is easily picked up from among a plurality of ceramic green sheets in each tray.

What is claimed is:

1. A manufacturing apparatus for manufacturing electronic monolithic ceramic components, the manufacturing apparatus comprising:

a sheet supplier for supplying a plurality of types of ceramic green sheets in a predetermined order, each ceramic green sheet lined with a carrier film and having a plurality of pin insertion holes that penetrate the ceramic green sheet and the carrier film, the sheet supplier including a plurality of trays, each tray being adapted to hold at least one ceramic green sheet with carrier film and plurality of pin insertion holes, the plurality of ceramic green sheets being held in the plurality of trays according to type, a rack for vertically aligning the plurality of trays, a tray drawer device for drawing trays from the rack according to a predetermined order, and rails arranged to guide a tray drawing operation of the tray drawer device;

a laminator for laminating the plurality of ceramic green sheets supplied by the sheet supplier, the laminator having a plurality of guide pins to penetrate the pin insertion holes while laminating the plurality of green sheets;

a conveyor device for picking up a single ceramic green sheet from a drawn tray and conveying the single ceramic green sheet to the laminator;

a compression bonder configured to press each ceramic green sheet lined with carrier film and placed on the laminator, to peel off the carrier film, and to discharge the peeled carrier film to a film discharger;

a processor unit adapted to receive data concerning at least a type, an order in lamination, and a quantity of ceramic green sheets necessary for a laminate for a desired electronic monolithic component;

the sheet supplier including a drive for driving the rack to be raised and lowered in a vertical direction; and

the tray drawer device being arranged to draw a particular tray from the rack when, as a result of the rack being at least one of raised and lowered by the drive, the particular tray is positioned at a predetermined height.

2. A manufacturing apparatus for manufacturing electronic monolithic ceramic components according to claim **1**, wherein at least some ceramic green sheets of the same type are stacked one above another in a single tray to form a stack of ceramic green sheets, and the conveyor device comprises a chucking device for chucking a topmost ceramic green sheet of the stack of the ceramic green sheets in the tray for conveyance.

3. A manufacturing apparatus for manufacturing electronic monolithic ceramic components according to claim **1**, wherein the rack moves along a single axis.

4. A manufacturing apparatus for manufacturing electronic monolithic ceramic components according to claim **1**, wherein the tray drawer device further comprises a chuck to travel along the rails, the chuck is both vertically and horizontally movable, and the chuck comprises pins to mate with each tray.

5. A manufacturing apparatus for manufacturing electronic monolithic ceramic components, the manufacturing apparatus comprising:

a sheet supplier for supplying a plurality of types of ceramic green sheets in a predetermined order, each ceramic green sheet lined with a carrier film and having a plurality of pin insertion holes that penetrate the ceramic green sheet and the carrier film, the sheet supplier including a plurality of trays, each tray being adapted to hold at least one ceramic green sheet with carrier film and plurality of pin insertion holes, at least two of the trays holding two different types of ceramic green sheet, respectively, the plurality of ceramic green sheets being held in the plurality of trays according to type, a rack for vertically aligning the plurality of trays, a tray drawer device for drawing the at least two trays from the rack according to a predetermined order, and rails arranged to guide a tray drawing operation of the tray drawer device;

a laminator for laminating the plurality of ceramic green sheets supplied by the sheet supplier, the laminator having a plurality of guide pins to penetrate the pin insertion holes while laminating the plurality of green sheets;

a conveyor device for picking up a single ceramic green sheet from a drawn tray and conveying the single ceramic green sheet to the laminator;

a compression bonder configured to press each ceramic green sheet lined with carrier film and placed on the laminator, to peel off the carrier film, and to discharge the peeled carrier film to a film discharger;

a processor unit adapted to receive data concerning at least a type, an order in lamination, and a quantity of ceramic green sheets necessary for a laminate for a desired electronic monolithic component;

the sheet supplier including a drive for driving the rack to be raised and lowered in a vertical direction; and

the tray drawer device being arranged to draw a particular tray from the rack when, as a result of the rack being at least one of raised and lowered by the drive, the particular tray is positioned at a predetermined height.

6. A manufacturing apparatus for manufacturing electronic monolithic ceramic components according to claim **5**, wherein the rack moves along a single axis.

7. A manufacturing apparatus for manufacturing electronic monolithic ceramic components according to claim **5**, wherein the tray drawer device further comprises a chuck to travel along the rails, the chuck is both vertically and horizontally movable, and the chuck comprises pins to mate with each tray.

8. A manufacturing apparatus for manufacturing electronic monolithic ceramic components, the manufacturing apparatus comprising:

a sheet supplier for supplying a plurality of types of ceramic green sheets in a predetermined order, each ceramic green sheet lined with a carrier film and having a plurality of pin insertion holes that penetrate the ceramic green sheet and the carrier film, the sheet supplier including a plurality of trays, in each tray the ceramic green sheets being sorted according to the respective type thereof and a plurality of ceramic green sheets of the same type being stored on each tray, a rack for vertically aligning the plurality of trays, each of the trays including the plurality of ceramic green sheets of the same type, a tray drawer device for drawing trays from the rack according to a predetermined order, and rails arranged to guide a tray drawing operation of the tray drawer device;

a laminator for laminating the plurality of ceramic green sheets supplied by the sheet supplier, the laminator having a plurality of guide pins to penetrate the pin insertion holes while laminating the plurality of green sheets;

a conveyor device for picking up a single ceramic green sheet from a drawn tray and conveying the single ceramic green sheet to the laminator;

a compression bonder configured to press each ceramic green sheet lined with carrier film and placed on the laminator, to peel off the carrier film, and to discharge the peeled carrier film to a film discharge;

a processor unit adapted to receive data concerning at least a type, an order in lamination, and a quantity of ceramic green sheets necessary for a laminate for a desired electronic monolithic component;

the sheet supplier including a drive for driving the rack to be raised and lowered in a vertical direction; and

the tray drawer device being arranged to draw a particular tray from the rack when, as a result of the rack being at least one of raised and lowered by the drive, the particular tray is positioned at a predetermined height.

9. A manufacturing apparatus for manufacturing electronic monolithic ceramic components according to claim **8**, wherein the rack moves along a single axis.

10. A manufacturing apparatus for manufacturing electronic monolithic ceramic components according to claim **8**, wherein the tray drawer device further comprises a chuck to travel along the rails, the chuck is both vertically and horizontally movable, and the chuck comprises pins to mate with each tray.

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